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Australia

SIMPLE TECHNIQUES FOR THE BULK HANDLING AND STORAGE OF FRUIT

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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SIMPLE TECHNIQUES FOR THE BULK HANDLING AND STORAGE OF FRUIT.

by E.G. Hall and J.D. Mellor, Commonwealth Scientific and Industrial Organization, Division of Food Preservation, Sydney, New South Wales, Australia.

1. Since its first introduction into the apple industry in New Zealand in 1953 several kinds of bins have been used successfully in Australia for the bulk harvesting, transporting and cool storage of apples, pears, citrus and, to a lesser extent, canning peaches. Bins, of more expendable nature, are also being used increasingly for the export of apples and pears to markets in the northern hemisphere.

2. Intelligently used, bulk handling can facilitate operations and both greatly reduce labour and container costs and capital outlay on equipment may be recouped within a few years. By bulk bins, larger net loads may be carried on transport vehicles, thus greatly reducing carrying costs on long hauls, and by their use in suitable cool stores a gain of up to 10% in storage space may be made. Also indirect saving may result from the fruit being less bruised and from the slightly longer storage life obtained.

BULK HANDLING

3. Harvesting. In small orchards trailer bins, mounted on pneumatic tyred wheels, are often convenient; or low level tip carts, may be used. In larger orchards bins may be left on a trailer and when filled hauled by tractor to nearby road transport or directly to the packing shed. In larger orchards bulk bins, placed conveniently on the ground, are lifted onto the transport lorry by retractable boom jib hoist (if fitted to lorry), by fork lift tractor or by manual labour. For longer hauls of bins from the orchard, special straddle trucks are often more economical.

4. Storage. With suitable equipment the filled bulk bins can be stacked in the cool store easily. After allowing for the small gaps between bins necessary for cooling, there is usually as much as a 10% gain in storage space. If the floor boards of the bins are spaced to 7-10% of the bottom open, a rapid cooling of apples, pears and also canning peaches is possible. Both packing sheds and cool rooms should have level, heavy duty floors, preferably of concrete. New packing sheds should provide plenty of floor space and cool rooms be built to accommodate bins stacked up to seven high, especially if electrically operated fork-lifts are to be used. Doorways should be sufficiently large for fork-lift operations and in cool stores be fitted with air curtains or other means of minimizing the entry of hot air.

5. Orchard Bins: Since they are used many times during the season.

Conway, T., Developments in mechanical and bulk handling of fruit. N.Z.J. Agric. 94: 534 (1957).

Hall, E.G., and Mellor, J.D., Bulk bins for fruit storage, Commonwealth Scientific and Industrial Organization. Food Pres. Quart., 22, 49 (1962).

bins used in the orchard must be of strong construction. They may have slatted sides and floors and are commonly made with a full width, top hinged side gate, 10in high and opening at floor level to permit fruit to slide out readily when the bin is tilted. Where fruit is to be washed it is often convenient to float it out of the bins.

6. Containers for Transport: For convenience of return the bulk containers, of metal or wood, for transport of fruit to packing stations or markets may be collapsible, or of a type that when empty, may fit into each other. Such kinds of containers are still very much in the developmental stage in Australia but a start is being made to transport citrus and apples in bulk from producing areas to processing or consuming centres. These fruits seem to travel much better in bulk than when packed in wooden boxes. It is of interest that potatoes are shipped successfully from the island State of Tasmania to Sydney and Brisbane in steel bins of approximately two tons (2,000 kilo) capacity.

7. Storage Bins: It is common practice in Australia for apples and pears to be placed directly in storage bins on picking and for grading to be carried out when the fruit is taken out of cool storage. Less common is the filling of the storage bins in the store with graded fruit.

8. Expendable Bins for Export: The use for export of expendable pallet base bulk bins holding 20-25 bushels (about 500 kilo) of apples or pears, which was pioneered in Australia, has enabled shipments to countries in the northern hemisphere, showing good out-turns of unbruised fruits.

9. Dimension of Bins: The dimensions of bulk containers have been varied according to the type of fruit, the transport and handling equipment available, and, on occasion, to meet other special requirements. Wherever possible bins should be of a standard size. Since, in Australia, the bodies of road vehicles are usually made to conform to a maximum loading width of 8 ft, square bins slightly under 4 ft x 4 ft and having an internal height of 2 ft have proved convenient. Figure 1 shows two types of bins, holding about 20 bushels of apples or pears, in common use in Australia.

10. Design: The design of bins should be such that they are durable, of rigid construction, and resistant to torsional stresses, with adequate pallet space and smooth internal surfaces. The floor boards should be spaced to leave 7-10% of the bottom open, especially when rapid cooling is required. Export bins, normally used only once, need not be so strongly constructed. Many export bins are made of hardboard well secured to a wooden frame.

11. Construction: To obtain strength and rigidity at reasonable cost experience has shown a type of bin, having 3 in x 3 in triangular corner posts with sides of $\frac{1}{2}$ in plywood or diagonally braced boards, not less than 3/4 in thick, to be satisfactory. (Figure 11) The sides may also be of hardboard, lighter plywood or vertical boards, attached to a diagonally braced frame. To minimize damage to the fruit the inside edges of the floor boards, placed $\frac{1}{2}$ in apart, need to be bevelled to a 20° angle. The clearance space left for the fork-lift in a pallet base bin should not be less than $2\frac{1}{2}$ in and preferably 3 in. For ready emptying a full width top-hinged side gate 8-10 in high is usually provided. Square shank twisted flat headed (pallet) nails should be used.

LIFTING AND MOVING TECHNIQUES

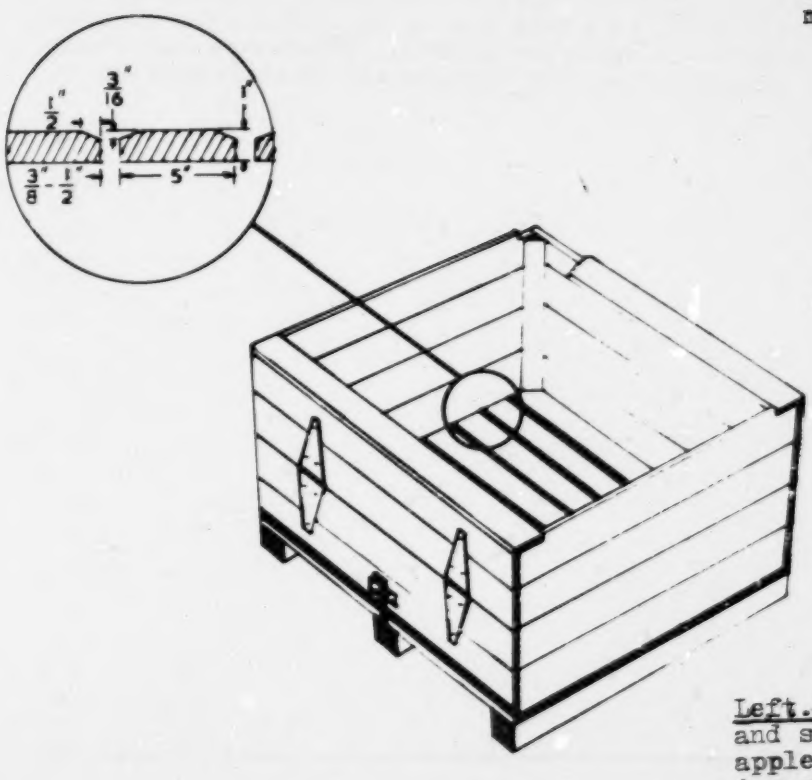
12. In the Orchard: Some form of fork-lift is necessary when handling palletized units. Most farm tractors, equipped with hydraulic lifting gear, can be easily fitted, either in front or rear, with fork-lift attachments. If the grower does not own a tractor, hooks or rings may be fitted to the bins to enable them to be lifted by a jib crane mounted on the transporting vehicle. The crane may also be used to unload the bins at their destination.

13. At the Packing Shed: On arrival at the packing shed or cool store the filled bins may be moved by fork-lift equipment, hoist, gantry, or a roller conveyor. Since the fumes of internal combustion engines may endanger the lives of the workers and have a deleterious effect on the fruit, fork-lifts used in cool stores or other confined spaces should be powered by batteries or manually operated. A cheaply constructed but efficient hand operated fork-lift may be used which has a lifting device operated either hydraulically or by means of a winch and cable. The usual way of emptying a pallet base bin is by placing it inaa support and tilting it through an angle of approximately 35° so that the fruit slides either directly into a hopper or on to a grader belt. The various types of equipment used in Australia for handling bulk bins have been described in some detail by Fleming and Wilson.

14. Trailer Bins: Trailer bins are most conveniently emptied by tipping them to allow the fruit to slide out on to a floor level conveyor which elevates them to a hopper or grader. Sometimes the fruit is fed directly into a hopper after the trailer has been backed on to an elevated ramp.

Fleming, C.B., and Wilson, A.G.L., Bulk handling of apples and pears, Tas. J. Agric. 31, 98 (1960).

Showing Fig. 1. Two types of bulk bins mounted on a trailer.



Left. Fig.II. Orchard and storage bin for apples and pears, showing method of construction, bottom venting, gate for removal of fruit.

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SIMPLE TECHNIQUES FOR THE BULK HANDLING AND STORAGE OF FRUIT.

by E.G. Hall and J.D. Mellor, Commonwealth Scientific and Industrial Organization, Division of Food Preservation, Sydney, New South Wales, Australia.

SUMMARY.

In Australia several kinds of bins are being used successfully for the bulk harvesting, transporting and cool storage of apples, pears, citrus and, to a lesser extent, canning peaches. Bulk bins facilitate handling, reduce labour and container costs, allow larger net loads of fruit to be transported and in cool stores save storage space. Expendable bins are being used for the export of apples and pears.

In many small orchards trailer bins mounted on pneumatic tyred wheels are used for harvesting. Low level tip carts drawn manually or by animals are an alternative. In larger orchards pallet bins lifted by tractor fork-lift are common, but a retractable boom jib hoist on a lorry can be used.

If the floor boards of the bins are spaced to leave 7-10% of the bottom open very rapid cooling of fruit is possible in cool stores. New stores should be designed to accomodate bins stacked up to seven high. Floors should be strongly constructed and doorways made wide enough for handling equipment. Orchard bins should be of strong construction to withstand much usage and have a full width, top hinged, gate opening one side, at floor level, to permit the fruit to slide out readily when the bin is tilted.

Bulk containers, of wood or metal, used to transport fruit to packing or marketing centres may, for ease of return, be made so as to collapse, or fit into each other. Even in road transport, citrus fruit and apples travel much better in bulk, than in small boxes.

Apples and pears are commonly placed directly in storage bins, grading being done when the fruit is taken out of cool storage.

Expendable pallet base bulk bins holding 20-25 bushels of apples or pears have enabled successful shipments to be made to markets in the northern hemisphere.

Bins should be of rigid construction with smooth internal surfaces and provided with adequate pallet space. General specifications are given in the paper. It is convenient to relate size to the usual maximum loading width of road vehicles, and square bins are most easily handled.

Most farm tractors equipped with hydraulic lifting gear can be fitted readily with fork-lift attachments for work in the orchard. If a hoist is used, bins should be fitted with hooks or rings.

Full bins of fruit on arrival at the packing shed or cool store may be moved by fork-lift equipment, hoist, gantry or roller conveyor. Internal combustion engines should not be used to power the lifting devices in confined spaces. A cheaply constructed, but efficient, hand operated fork-lift and means for emptying trailer bins are desirable.

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Agenda Item: D.7

United States of America

THE IRON AND STEEL INDUSTRY IN A DEVELOPING ECONOMY

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE IRON AND STEEL INDUSTRY IN A DEVELOPING ECONOMY

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I. INTRODUCTION

1. The establishment of an integrated iron and steel industry in a developing economy creates a great new driving force which experience demonstrates provides the basis for rapid economic, industrial, and social growth, and the decision by a developing nation to create an iron and steel industry begins a long chain of events which require the most careful and professional planning in a large number of fields.

2. Before a decision of this magnitude is made, responsible officials need to weigh carefully the many considerations involved. This paper is intended to be of assistance in this regard and is divided into three parts: First, prerequisites for building an iron and steel plant; second, the benefits which accrue to the economy when a basic iron and steel industry is established; and third, the step by step evolution of such a project.

II. PREREQUISITES FOR BUILDING AN IRON AND STEEL PLANT

3. Despite the attractiveness of the idea of creating an iron and steel facility, there are definite prerequisites which must be fulfilled before any steel mill project can be wisely undertaken. This cannot be overemphasized.

4. Whether or not these prerequisites can be fulfilled, however, can be determined only through a very careful survey and analysis by specialists in a number of key areas. These prerequisites are: -

(a) Adequate markets -- based on present consumption and predictable growth to support a minimum economic sized plant.

(b) Adequate raw materials at reasonable cost.

(c) Adequate transportation at reasonable cost for raw materials and finished products.

(d) Good site location accessible to raw materials (including water), markets and labor supply.

(e) A satisfactory financial plan for construction and operation of the plant.

A. Adequate Markets

5. None of the benefits of an iron and steel industry is possible, unless there is a sufficient internal market for steel products to support an economically sized steel producing facility. Therefore, the first step to be taken to determine the economic feasibility of establishing a steel industry is to undertake a well-planned market survey. Quantities of iron and steel imported in the past serve as a convenient starting point.

6. If the statistics available in the country are inadequate to establish this point, then this information can be obtained from the records of importers of these products. To predict the future growth is sometimes difficult because, in a rapidly developing economy, previous economic history is not indicative of future growth after steel products become available locally at steady prices. Prediction of future trends depends upon a study of conventional indices; such as, the gross national product, population growth and combination of statistical facts which may seem reasonable and relevant in the light of present conditions. Of special significance here, is the use of information on trends in other developing nations comparing what has happened before and after the building of the steel plant.

7. Once total steel consumption has been established, it is necessary to spell out the various end uses of the products. These end uses include such things as reinforcing rod for concrete construction, round rods for wire and nails, small angles and channels for construction, pig iron for independent foundries, structural shapes for construction of buildings and machinery, flat sheets for siding and roofing, utensils and hollow enamelware, containers, and tinplate.

8. The quantity of each of the products which the mill is to make must then be carefully estimated. This information is used to determine the size of mill to be designed to satisfy the markets immediately available, and as projected for the immediate future. It is important to understand that it is seldom practical to propose a plant that will make all of the sizes or all of the types of steel products that have been imported in the past. It would not be economic to make a small quantity of a given product, particularly if the market forecast for this product were also small. Therefore, it is necessary to design the plant to produce the greatest number of those products which it can make most economically.

9. It is interesting to note that in steel plant projects in developing economies there is a pattern of growth which usually begins with the production of merchant products required for construction applications, such as concrete reinforcing bars and angles, and then proceeds eventually to flat steel products necessary to a more highly industrialized economy.

10. Consideration of all these factors will result in an estimate, by classification of products and individual sizes, of the total iron and steel requirements for the next ten years which is about as far ahead as one can make a reasonable prediction.

B. Raw Materials

11. Accessibility of adequate raw materials at a reasonable cost is vital to the development of the plant. And as it will be necessary that proven reserves, or assured sources, of the various raw materials shall be available to serve the plant for a period of 20 to 25 years, a scientific program of drilling and testing under competent supervision must therefore be undertaken. This program must prove not only the quantity of the raw materials available, but also their physical and chemical characteristics. The costs of mining and transporting

these raw materials to the plant site must also be established, and these costs must be reasonable or the economic soundness of the entire project may be jeopardized. If insufficient quantities are available, or poor qualities of raw materials are encountered, it may be necessary to consider importing such materials, or at least importing a portion of the total requirements, if the economics justify doing so.

12. A firm commitment for adequate supplies of these materials must be obtained at definite prices on which to base the economic viability and financial projection of the project.

C. Transportation

13. Next comes accessibility and transportability of raw materials at a reasonable cost. Also, consideration must be given simultaneously to the cost of moving the finished products of the plant to consuming markets. Excessive costs here, even with all other factors favorable, could defeat the project.

14. The most desirable and cheapest form of transport is by water; that is, river, lake or ocean. Other methods of transport are railroad, aerial ropeway, and highway. Each method has its own pros and cons as compared with the others. Hence, it is necessary to make a thorough investigation of the cost of transport of materials to and from the various plant sites selected for investigation.

D. Plant Location

15. Plant location can often make the difference between profit and loss in steel plant operation. In addition to the obvious factors of accessibility to raw materials and markets, and the cost of transportation, the land must be obtainable at a reasonable cost. The land must also have good soil-bearing conditions to carry the heavy loads and not require extensive piling or other site-preparation costs. In addition, the site must provide adequate supplies of potable and process water and be situated so that it will be easily served by good housing, schools, hospitals, utilities and other facilities for workers and their families. Highways, roads, airports, waterways, transportation service into the plant are also required for a well located plant.

16. In the event that it is necessary to locate the plant in an undeveloped part of the country, it may be necessary to construct a complete town site at that location, and provide all the necessities of a town or village. When this happens, it adds to the economic burden of the steel plant project if the cost of these facilities must be charged to it. Experience indicates, however, that local governments are often willing to subsidize the town site development in order to make the project possible, to decentralize their industries, and to bring about the development of a new portion of the country. In this event, the iron and steel plant is relieved of this financial and administrative burden.

E. Financial Plan

17. Sufficient funds must be provided on reasonable terms to finance the construction and initial operation of the plant. The loans must be on a long enough term and at low enough interest rates to permit the plant to be economically viable.

18. With satisfactory answers to these five prerequisites, possible benefits may now be evaluated and the characteristics of the project determined in terms of plant design, capital cost, financing and plan of operation.

III. BENEFITS

19. It is well known that the consumption of iron and steel products is a barometer of economic, technical, and social growth. Examples could be cited showing that the advent of an iron and steel plant in some of the recently developing nations resulted in economic advancement. In addition, the development of an iron and steel industry promotes certain other immediate benefits which include local availability of steel products as compared with imports, large-scale employment of local labor, and conservation of foreign exchange.

20. While the primary benefits created by the introduction of an iron and steel industry are of great importance, the other benefits which are in turn created play a very significant role in spurring economic growth. For instance, it has been learned by experience that for each individual employed directly in an iron and steel mill approximately eight to ten persons will find employment in supporting industries such as the mining of iron ore, coal and limestone, and in the transportation services associated with the plant. A tertiary effect is the generation of other smaller servicing businesses that find their mainstay of support in the industries created. In addition to this, as a result of local availability of steel at steady prices a wide variety of consuming industries come into being for converting the steel mill products into finished and semi-finished goods. The local steel mill provides a basis for confidence among people who desire to go into business because they are assured of a steady supply of these steel products.

21. Because of their need to import a large number of finished products, many developing countries find themselves with a major problem of conserving foreign exchange. Hence the introduction of an iron and steel industry and the substantial reduction of iron and steel imports which this brings about make it possible to conserve foreign exchange and bring the economy of the country into better balance. The full realization of this saving is made possible when the raw materials for the production of steel are indigenous. Quite obviously, if a steel mill were built on the premise of importing some or most of its raw materials, the advantage which would accrue to the country would be correspondingly reduced.

22. Because the greatest quantity of products needed initially by a developing economy follows a pattern, it can be stated that even a small steel plant with a capacity of only 150,000 metric tons per year producing only a partial range of steel products well selected according to local market demand may be able to supply a very large percentage of the total finished steel requirements.

23. Thus we find that in most cases the creation of an iron and steel industry in a developing country introduces a dynamic, driving force that provides a real basis for rapid economic, industrial, and social growth.

IV. EVOLUTION OF AN IRON AND STEEL PLANT

A. Size of Plant

24. Using the information furnished in the market survey, it is possible to determine the size of plant which should be built to satisfy the market for the various products required by the economy. It may be that the required quantities of one product are insufficient to justify expenditure of huge sums for the specialized equipment necessary for its production. For example, if a country had a market for a small quantity of high quality tinplate for its canning industry, say 20,000 tons of electrolytic grade, and had no use for other flat

products, it would be impractical - cost-wise - to build a good flat product mill to produce such small tonnages of this high quality product. The same would be true if a small quantity (say 5,000 tons) of large structural members or a small quantity of railroad rails were required. Providing the facilities for such small-scale production would increase costs beyond the point of economic feasibility.

25. It is necessary, therefore, to decide on a plant of such size as to produce economically the greatest possible number of products required by the growing economy.

B. The Iron-Making Process

26. Once the size of plant has been determined, and the raw material costs and availability established, it then becomes necessary to select the iron-making process best suited to that size of plant and those raw materials. In some developing countries the selection of a suitable iron-making process is much more complex than in the highly industrialized nations of the world due, generally, to the small plant capacity required coupled with the lack of one or more of the basic materials in the quality and quantity usually considered acceptable. Subject to the availability of raw materials and the planned size of plant, any of the following processes may be adopted:

(a) Blast Furnace - The conventional blast furnace normally operates with high grade, lump iron ore (or sintered or pelletized iron ore) which is low in contaminants such as titanium, zinc, nickel, chrome, copper, and the like. A good grade of metallurgical coke must be used. This type of furnace is highly efficient and is preferred when the capacity required is sufficiently high, and when high grades of iron ore and coking coals are available. It is ideally suited to continuous operation at larger tonnages. If smaller tonnages are required, however, and if good grades of iron ore and coking coal are available, and electric power can be furnished at reasonable rates, then consideration might be given to the iron-making process described below.

(b) Submerged Arc Electric Smelting - The submerged arc electric smelting furnace may be built for capacities as low as 100 metric tons of pig iron per day. The advantages of this furnace over the blast furnace described above are that it can give acceptable economics at smaller tonnages, and it uses electricity which may be available and cheaper than other sources of heat. The major disadvantage is that, in the larger sizes, it costs more to produce pig iron by this method than by the blast furnace under normal conditions.

(c) Electric Reduction Processes - The need for a process that can treat off-grade iron ores, or can use non-coking coals with low or high grade iron ores, has been evident for many years. During the past few years a number of such electrical reduction processes (often referred to as direct reduction processes) offering certain technical and economic advantages have evolved. After an exhaustive study of those developed in the past ten years, Koppers Company decided that the Strategic-Udy process is the best of these processes applicable to the above conditions. The Strategic-Udy iron-making process heats and partially reduces the iron ore, coal, and limestone in a rotary kiln. This heated and partially reduced mixture is then introduced as a free-flowing sinter into an electric furnace where the final reduction takes place. It is not able to compete with the blast furnace when tonnages are large and other conditions are proper for that type of operation. However, if the capacity of the plant is small, if the available iron ore contains copper, nickel, chrome, titanium, or the like in substantial quantities, or if only non-coking coal, anthracite or lignite is available, the Strategic-Udy

process can produce pig iron under these conditions which are technically and/or economically unsuitable for the blast furnace or the submerged arc electric furnace. The significant advantage to a developing economy of using the Strategic-Udy process is that it may use the locally available source of non-coking coals and off grades of iron ore. The same coals (whether lignite, anthracite, or non-coking bituminous) may be used also to produce comparatively low cost electric power. Especially significant to the developing nations is the fact that this process, operating at a capacity of approximately 100,000 metric tons per year, can produce pig iron cheaper than the conventional processes operating at this capacity. In addition, this process can make full use of fine iron ores without sintering.

(d) Scrap Melting - Still another alternative exists for the developing nation, namely, the melting of available scrap. However, a scrap melting operation generally serves as only the beginning of a steel plant since such an installation is dependent upon the continued availability of scrap. In some nations there exists initially sufficient scrap to support such a facility but the scrap gradually disappears and imports of scrap are required, depleting the foreign exchange which most developing nations are attempting to conserve. The process unit in which the scrap melting can take place depends upon many factors, the most important being the source of heat. A cold charge open hearth furnace may be used, fired either by oil or gas. If there is reasonably priced electric power an electric melting furnace is ideal, followed by the usual metal processing facilities as dictated by economics. If electric power is not readily available in sufficient quantities, then the hot blast cupola offers certain advantages for the production of pig iron. The hot blast cupola, however, requires the use of metallurgical grade coke. In some of the developing nations, pending development of a market sufficiently large to support an integrated steel plant, it may be advantageous to start with a scrap melting operation to be expanded later to include more basic metal producing facilities. However, because of the need to furnish scrap iron from local sources on a continuing basis, the plant would have to be small in size and would, therefore, be capable of producing only a limited line of products. If the initial requirements were small enough, however, this initial plant could be designed for later expansion into an integrated iron and steel plant.

C. Steel-Making Process

27. The selection of the process for converting the pig iron or molten iron to steel is also a vital decision. It is dependent on the type of iron produced from the raw materials and the capacity of the installation under consideration. Each of the various available processes has unique advantages and disadvantages.

28. About sixty years ago most steel manufactured in the world was made by the so-called "Bessemer Process" which consisted of blowing air through the bottom of a refractory-lined vessel containing molten iron. In the United States, Bessemer steel was all made in acid or siliceous refractory-lined vessels and it was necessary that the molten iron be low in contaminants such as phosphorus and sulphur, since neither was removed in the process. In some parts of Europe, a similar pneumatic process became widely used with vessels having a basic refractory lining which was necessary because of large amounts of phosphorus in the molten iron which had to be removed by means of a basic flux such as lime. The process of making steel by this method from high phosphorus iron came to be known as the "Thomas Process". Both of these pneumatic processes produced steels limited in their useful application since they are relatively high in nitrogen which was picked up from the air blast.

29. About 1870, the open hearth steelmaking process was invented by Siemens. Adoption of this process in the United States was very rapid and, by 1905, about half of all steel ingots produced in the United States was made by this method. Use of the process continued to spread and, by 1951, it accounted for approximately 87% of the steel producing capacity of the United States. This process permits a wider range of quality steels than the Bessemer Process.

30. Some years ago steel manufacturers began using relatively pure oxygen as the oxidizing agent, the iron being contained in a vessel similar to a Bessemer shell. Oxygen at high pressure was applied to the molten iron by means of a top lance. This process has gained increasing favor in the past 10 years because it makes steel of as high a grade as the open hearth and because, for a new installation, the initial capital investment is likely to be lower.

31. If reasonably priced electric power is available, electric refining furnaces may be economical to use due to their inherent flexibility and adaptability to comparatively low capacities.

32. There are other generally accepted and widely used methods of refining pig iron into steel, but, for the purposes of this paper, the discussion has been narrowed to the better known and more widely used processes.

D. Billets and Slabs

33. The selection of a method for the production of billets and slabs is of vital significance. Billets are normally square bars varying in size from 2" x 2" to 8" x 8" from which merchant products are made.

34. Slabs, rolled to produce flat products such as sheets and plate, vary in thickness up to 12" and in width up to 75". The type of process used to produce these billets and slabs has a direct bearing on the cost of producing the finished products as well as on the initial capital investment.

35. In small size plants where large capital investment cannot be supported, a method of producing billets and slabs directly from the molten steel has been developed; - the continuous casting process. In such a process the slabs and billets are continuously cast and cut into desired lengths by means of an oxygen-acetylene torch.

36. By eliminating the need for ingot molds, soaking pits, blooming and slabbing mills, and billet mills, initial capital investment and production costs are reduced. It is probable that the continuous casting process would be more appropriate for a developing nation whose market is in process of expanding.

E. Rolling Mills

37. It is necessary to determine which combination of rolling mills will most economically produce the immediate requirements and, at the same time, have excess inherent capacity to take care of the future demand predicted by the Market Study. Normally in a developing economy smaller merchant products such as rods for concrete reinforcing, small angles and channels for building construction, and round rods for wire and nails constitute the bulk of initial demand. These items can be produced economically, if nothing more is needed, in a smaller merchant mill. Next, the economy begins to demand larger steel sections and shapes. However, a much larger capital investment is required and, a greater demand for these products is necessary to justify the additional facilities.

38. As the economy continues to develop a market is created for flat products; sheets and plate. The market study will have determined current and future demand of the types of flat products required. Many countries embarking on an industrialization program have need for a small quantity of flat products - sheets and plate for corrugated roofing and siding, black sheet for hollow enamelware, for barrels and cans, and for tinplate. This need may amount to only 40,000 or 50,000 metric tons and, therefore, a large reversing hot strip mill or the even larger capacity continuous hot strip mill could not be justified.

39. A possible solution to this situation and one that has been used in many countries is the hand sheet mill which, as its name implies, uses more manual labor in its application and less highly automated machinery. The hand sheet mill has the advantage of a lower economic break-even point and consequently is well suited to fulfill the requirements of a smaller market.

40. Unit cost of production of the hand sheet mill will be higher than that of a continuous hot strip mill producing above its break-even point but the unit cost could be far less than that of the larger mill if the latter were producing only 40,000 to 50,000 tons of product.

41. It is necessary, therefore, to design the rolling mills to take care of the immediate needs of the market, as projected to the end of the first five years of operation (this will normally be eight to ten years after it has been decided to build the plant) -- so as to produce the most product for the least capital and operating cost.

F. Source of Electric Power

42. The source and cost of electric power is important to the steel-making facility whether it is based on the conventional iron and steel making processes, or based on electrical reduction and refining processes. In the latter cases, it is more important and forms a larger part of the iron and steel-making cost -- supplanting the coal or coke in part. But whatever the iron and steel making processes, the cost of electric power is important to the operation of the rolling mills and the multitude of auxiliaries used throughout the plant. In many nations sufficient local power exists in the form of hydroelectric or thermal plants. The use of these particular sources are, to a large part, dependent upon the availability of power in adequate quantities, and dependability of the supply.

43. In many instances, due to the unusually large demands and an already overloaded grid, it has been found both practical and economical to construct captive power plants. This has the added advantage of giving complete control of the power source to the steel plant management and is not subject to power interruptions due to breakdowns in the distribution system outside the plant boundaries.

G. General Facilities

44. Provision must be made within the plant boundaries for other utilities such as potable and process water, electric lighting and power, sewage, etc. as well as roads, railroad, repair shops, warehouses, first aid stations, and the like. If the steel plant is located in a remote area, it may be necessary to build shops capable of repairing almost any of the equipment in use in the plant. This will necessitate the establishment of the following maintenance departments:

(a) Mechanical
(b) Electrical
(c) Mason
(d) Blacksmith and Welding

(e) Carpentry
(f) Instrument Repair
(g) Locomotive and Car Repair
(h) Auto and Truck Garage

45. The Utility Department controls the supply of water, power, steam, oxygen, compressed air, etc. It is responsible for the maintenance of all potable and process water lines as well as fire lines; for the operation and maintenance of power generation and distribution facilities as well as tie-ins with other utilities.

H. Adequacy of Infrastructure

46. In selecting the location for a steel plant consideration must be given to the availability (or lack thereof) of all facilities (the infrastructure) needed to support such a plant. In general, these facilities may be divided into those required for the people working in the plant and those required to support the plant itself. The workers and their families need housing, schools, churches, hospitals, stores, water, lights, sewage, transportation, and other facilities.

47. The plant requires developed highways, railroads, and/or waterways for low cost transport of raw materials and supplies to the plant, and finished products to the consuming market. Potable and process water must be brought to the plant and effluent taken from it. Electric power, fuel oil, natural gas, or other power sources must be made available.

48. Before any plan can be finalized for the construction of a steel plant, all of the infrastructure problems must be solved - who will furnish the services, or the money to supply them. Wherever possible, it is highly desirable that all supporting facilities (the infrastructure) be supplied to the steel plant so that it is not burdened with the cost of the facilities or their administration. The steel plant is then left to its primary task of making steel.

I. Profitability

49. Because of the heavy initial investment required for a steel plant, large capital loans are needed to finance the construction and operation of the plant. These loans, obtained from private and public financing institutions, must be repaid with interest. In addition, shareholders will demand that they be given a fair return on their investment. Therefore, the steel plant must be designed to hold all costs to the minimum so as to make it a profitable operation.

50. Private enterprise, working in cooperation with government, mindful of its duties to produce efficiently and for profit, should be the goal for the majority ownership of the steel plant. Many governments have stated their intention of supporting private enterprise by agreeing to sell their interests to the private sector as private investment capital becomes available.

51. Profit, of course, is the difference between income (which is the total value of the steel products sold) and cost (which is the sum of the direct operating cost, the overhead expense and the financing charges). Therefore, the selling prices of steel products which create income deserve our consideration. In most instances, it has been found that prices being paid for steel by non-steel-producing countries are high enough to justify construction of local steel plants (provided raw materials, power and other necessities are available). If the plant is small, steel products cannot be provided as cheaply as they can be produced in the huge mills in Europe or America. It may require, therefore, that the new small plant be given a modicum of protection by its government during its formative years. It normally will not be

necessary to raise tariffs, but it may be necessary to continue existing tariffs for a period of years. In addition, provision may have to be made to prevent the sale of steel products in the local market at exceptionally low prices during periods of over-production in the larger mills abroad. This protection may take the form of a program of import licensing for the products produced by the new local steel mill.

52. It is, therefore, essential to the economic viability of a project that decisions as to raw materials, location of the plant, source and cost of electric power and methods of transport, be made strictly on the basis of economics. This is true because a small new mill with its high capital charges, newly trained operating and management personnel, newly developed sources of raw materials and services, must be given every possible assistance to stand on its own feet without subsidy - and to make a profit for its owners, public or private, so that it may grow and expand - and assist in the industrialization of the nation.

J. Corporate and Capital Structure

53. The corporate structure of the steel plant will depend on the source of capital and the policy of the government. In most developing countries there are insufficient funds in the private sector to finance the development of a steel mill, and the local government may furnish some or all of the funds. In such cases, the local government may pledge itself either to take a subordinate position to private owners, or offer to sell its shareholdings to private owners in the future. The capital required to build and operate the plant normally comes from two sources; the shareholders or owners of the business, and long term loans from private and public lending institutions.

54. Although steel is a basic industry, it is not one in which high profits can be expected. At the same time it is an industry in which capital requirements are high. It is desirable, therefore, that loans provide a substantial part of the capital required to build the plant, that these loans be long term, and that the interest rate be reasonably low.

55. A medium size steel plant producing an adequate mixture of steel products has an excellent chance of success provided the following conditions exist:

(a) Adequate market for its output
(b) Suitable long-term debt financing
(c) Reasonably established sales prices for its products
(d) Adequate raw materials and power reasonably priced
(e) A mutual determination by government and business for its success.

56. An important source of long term loan capital has been the various lending institutions in Europe and the United States, both public and private.

57. Another source of financial assistance has been the equipment suppliers who have been willing to extend long term credits for the purchase of their equipment. In some instances these suppliers have assumed a financial interest in the operation by purchasing shares of stock in the company.

58. The raising of capital within the borders of the nation through the sale of stock to insurance companies, banks, and other lending institutions, and the general public is recommended since this insures active participation by those most affected by the results of the steel plant.

59. At the same time, it helps to develop the private sector as a moving force in developing the industrial strength of the nation.

K. Technical and Management Assistance

60. The management and operation of a steel plant is a complex task requiring many highly trained specialists in many different fields. It is not to be expected that all of these qualified specialists will be available in a developing country and it will, therefore, be necessary to import additional specialists. The number of such imported technicians and managers will depend on the local availability of skilled technicians and managers, and the number of local employees who can be trained during the period of plant construction. However, specialists have to be imported at the start to inaugurate an interim program for training local personnel immediately - training in all phases of plant operation and maintenance, as well as training in management and administration not only on-the-job but also abroad. The President, Sales Manager, Plant Manager, Plant Superintendent, Safety Director, superintendents of the various departments, the chief of the laboratory, the operators of furnaces and rolling mills, the superintendents of electrical and mechanical maintenance, must be trained to assume their responsibilities. As soon as they are qualified the imported specialists are released.

61. It is vitally important, therefore, that the company selected to furnish the technical and management assistance to the new steel plant be one with a background and history of achievement in this field where unusual technical ability and previous experience are so vital.

62. The objectives of the technical and management assistance group must be to obtain the most efficient and economical operation of the steel plant and to complete the training of the local employees of the plant at the earliest possible date so that they themselves can progressively assume in the shortest possible time all the management, administrative, and technical positions in the plant.

63. If competent personnel are available for the management, administrative, and supervisory positions in the office and in the plant, then the technical assistance group will furnish only advice and guidance in the execution of their duties. If, on the other hand, such personnel are not available locally, then the technical assistance group will help the steel plant recruit adequate talent from abroad, and supervise the training of local personnel to take over these responsibilities after a period of training. It is necessary that the technical and management assistance group align themselves with the steel plant on a long-term, continuing basis because it takes many years to bring a steel plant into full and efficient operation. When that point has been reached, the plant will undoubtedly have to be expanded to take care of the market for steel products which has been growing rapidly because of the availability of locally produced products at steady prices.

V. CONCLUSION

64. And so, as emphasized at the opening of the discussion, when a developing country has economically and technically usable raw materials and a sufficient market for steel plant products, building its own iron and steel industry will usually benefit its entire economy, expand its industrial base, and accelerate its social progress.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.7

United States of America

THE IRON AND STEEL INDUSTRY IN A DEVELOPING ECONOMY

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE IRON AND STEEL INDUSTRY IN A DEVELOPING ECONOMY

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I. INTRODUCTION

1. Establishment of an iron and steel industry in a developing country introduces a dynamic driving force which can bring about an acceleration of economic, industrial, and social growth.

2. The decision to build an integrated iron and steel plant in a developing country involves detailed consideration of many factors. This paper discusses the prerequisites for building a successful iron and steel plant, the benefits to be gained and the evolution of such a facility in a developing country.

II. PREREQUISITES FOR BUILDING AN IRON AND STEEL PLANT

3. Not every nation can support its own iron and steelmaking industry. There are certain prerequisites for success.

4. The first need is an adequate market and the existence of such a market must be determined by a survey conducted by unbiased professionals.

5. Having established a need, the next step is to explore the vital question of availability of raw materials. They must exist in sufficient quantities, in the right places, and they must have the required properties.

6. A third requirement is adequate transportation facilities to move raw materials to the plant and the finished product to the consumer.

7. A fourth requirement is a good plant site. Proximity to raw materials, to economical means of transportation, to a suitable labor force, and to the market must be analyzed.

8. Financing the operation is not the least of the problems encountered. A favorable political climate and a satisfactory division between equity and debt financing will stimulate interest in the project abroad.

III. BENEFITS

9. Many benefits will accrue as a result of local production of iron and steel. Rapid industrialization of many nations dates from the establishment of an indigenous iron and steel industry.

10. Local manufacture of iron and steel provides employment in the developing country, and the knowledge of an assured source of steel at steady prices results in an increasing number of fabricators providing an ever-widening circle of employment.

11. The possibility of conserving critical foreign exchange is another factor worthy of careful consideration. A nation which is attempting to industrialize and is forced to spend more than half of its limited foreign exchange for the purchase of iron and steel products must consider seriously the possibility of establishing its own iron and steel capabilities.

IV. EVOLUTION OF AN IRON AND STEEL PLANT

12. The market survey must give useful information on the quantities and types of products needed immediately with projections into the future. A decision must be made to build the size of plant that will produce most economically the greatest number of products required.

13. The choice of iron-making process depends on the quantity to be produced and the types of available raw materials. The conventional blast furnace is appropriate if high grade ore and a good grade of metallurgical coke are available. Many developing nations, however, have cheap sources of electrical power and a relatively small consuming market. In this case, consideration should be given to an electric smelting furnace or to one of the so-called "direct reduction" processes. Some of the latter processes are appropriate when only non-coking coals and/or low grade ores are available.

14. For conversion of iron to steel, the Bessemer, the Thomas, the open-hearth, the top blown oxygen converter, and the electric refining processes, all with improvements and innovations, are some of the possibilities. Each has unique advantages and disadvantages and the problem is to select the one best suited to the specific operation in question.

15. Another range of choices exists in the selection of methods for producing ingots, billets and slabs, merchant or flat products. Process and equipment selected must suit the local situation.

16. Availability of reliable power, adequacy of infrastructure, profitability of the overall operation, and corporate or capital structure of the undertaking are other factors which must be considered in deciding the economic feasibility of building an iron and steel plant.

17. In evaluating the factors enumerated above and to assist in making vital decisions that will affect operations for years to come, a developing nation is well-advised to obtain the services of qualified experts to assist in the planning, supervise the construction, and train personnel both at home and abroad for the operation of the facility.

V. CONCLUSION

18. When a developing nation has a need for iron and steel and possesses the required raw materials, building its own iron and steel plant will conserve foreign exchange, will create thousands of new jobs, will permit a more rapid expansion of its industrial base, and will accelerate its rate of economic and social progress.

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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : D. 7. 3

United States of America

THE DIRECT REDUCTION OF IRON AND THE LESS DEVELOPED AREAS

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THE DIRECT REDUCTION OF IRON AND THE LESS DEVELOPED AREAS

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Introduction

1. It is becoming apparent that revolutionary changes will occur over the next one or two decades in the world iron and steel industry. These changes will take place in two directions--in world iron ore trade, and in the construction of numerous small steel plants.

2. There are two driving forces which will bring this about. One is new technology which will permit large tonnage, low capital investment direct reduction operations to be carried out economically so that world trade in direct reduced iron as feed stock for the iron and steel industry will become practicable. The second is the rising tide of nationalism with its inevitable drive to promote local industry both in the form of small steel plants based on direct reduction as well as large plants for processing iron ore to the upgraded, reduced form, thus adding to the value of exports.

3. Steel production is the basic industry of the world's major powers. In fact, one can trace the history of the emergence of the great nations by their ranking in iron and steel production at any time over the past two to three centuries.

4. The fact that the annual steel output of the European Common Market has now reached 81,000,000 tons is a prime factor in the rapidly rising importance of this federation.

5. The great significance of steel to our civilization is more eloquently stated in an inscription on a French monument, "God made iron that men need not be slaves."

6. That the leaders of the less developed nations are well aware of the importance of establishing a steel industry is evidenced by the fact that international banking organizations such as the World Bank have been besieged with proposals to finance steel mills. Most of these proposals are unsound when analyzed by the international bankers on the basis of conventional technology and economics. Generally, this is due to the fact that the justified capacity is too small for the giant-sized conventional blast furnace steelmaking complex. Yet, there is little doubt of the need of a small steel mill in many of these less developed areas. One has only to look at the pattern of imports of these developing countries to realize that a small merchant rolling mill would supply nearly 60% of their steel requirements. Such a mill would save foreign exchange so important to the economy of these less developed nations, as well as provide employment. Ideally, such mills would consist of electric steelmaking furnaces for melting and refining scrap, facilities for casting into billet sized ingots, and a small versatile merchant rolling mill. Such facilities are common in selected locations in North America. The types of steel required for these products are not difficult

to produce and do not require the degree of skill necessary for the more sophisticated flat rolled product. What then is the problem? Could not such mills be built in the less developed areas and would they not be economical?

7. The difficulty with this solution is that it assumes that scrap of adequate quality and reasonable cost would be available to such a mill. Generally speaking, scrap is available only in the highly industrialized nations where steel has been produced for many years and where per capita consumption is now high.

8. The problem then is to provide means for producing a scrap substitute or melting stock at low cost from local raw materials (iron ore and fuels). Direct reduction represents a method of providing this melting stock (reduced iron) to supply the melting and refining operation of these small local mills.

9. What is direct reduction? Direct reduction has been defined in the past as the reduction of iron oxide at temperatures below the melting point of the reduced iron, and processes to accomplish this have been used since prehistoric times. However, direct reduction has now come to mean the reduction of iron ore in apparatus other than the pig iron blast furnace. We intend to show that some of the recently developed direct reduction processes represent a new dimension in the steel industry, both in terms of small steel plants and world trade in prereduced iron ore, which will be particularly important to the less developed areas. To fully understand the opportunities one must appreciate how the world's iron ore and steel industry presently operates and its changing economic and technological trends.

The Modern Large-Scale Steel Plant

10. The steel business as practices in the highly industrialized nations of the world is a very large industry. Iron is the dominant industrial product of our era. The coke blast furnace is the foundation upon which this industry stands. These large-scale integrated steelmaking operations have evolved and developed in those areas of the world where the three basic raw materials for the blast furnace--coking coal, limestone, and iron ore--could be brought together economically. Steelmaking in large integrated plants is carried out in three basic steps: 1) reduction of iron ore in the blast furnace; 2) conversion of the blast furnace molten pig iron (hot metal) and/or scrap to steel in steelmaking furnaces (open hearth, Bessemer converter, oxygen converter, or electric furnace) producing ingots (cast steel in primary form); and 3) finishing on rolling mills which break down the ingot to blooms, billets (small primary forms), and then to semi-finished steel products such as sheet, strip, rods, bars, plate, structurals, rails, etc. It is the first two steps up to the ingot stage of this process with which we are concerned.

11. The single, most important recent technical development in the steel industry is oxygen steelmaking, both in the oxygen converter and by oxygen injection into the open hearth or electric furnace. In either case, steel is now being produced in large integrated mills by the rapid oxidation of impurities in the molten pig iron (from the blast furnace) with gaseous oxygen. This new technique has resulted in increased production of steel per steelmaking furnace (open hearth or converter) and per man hour. For example, an open hearth furnace operating without oxygen on a conventional 50% hot metal, 50% scrap charge will produce steel at an average rate of 15-20 tons per hour. This same furnace with oxygen injection will produce steel at the rate of 30-40 tons per hour. Large oxygen converters have been built which produce up to 180 tons per hour. Oxygen steelmaking has resulted in increased demand in the steel mills for hot metal and has, therefore, emphasized the need to improve blast furnace operation.

12. Blast furnace output can be improved in many ways, most of which are additive. However, the most effective method is through the use of chemically and physically beneficiated raw materials. Today, the blast furnace operator is looking for the highest possible grade of ore and is expecting that it be physically prepared in the form of pellets or sinter. Furnaces fed with such prepared burden material operate more smoothly, produce more hot metal, and require less coke, with the result that the potential capacity of existing blast furnaces has been steadily increasing. The average iron content of the iron-bearing materials charged to the blast furnace in the United States has been steadily increasing, as is the proportion of physically prepared iron ore in the form of sinter and pellets in the blast furnace burden.

13. To offset the cost of these more expensive raw materials, the furnace operator is trying to effect further savings in coke by employing such techniques as injecting other fuels such as coal fines, natural gas, or liquid hydrocarbon fuels into the tuyeres of the blast furnace. Through the use of these improved techniques employing higher grade or beneficiated ores, physically sized burdens, higher purity coke, high top pressure, higher temperature hot blast, and blast moisture control, modern blast furnace operation is fast approaching the equivalent of minimum theoretical coke rates of 1050 to 1100 lbs. of coke per ton of iron. The next major step that can be taken to further increase productivity and reduce coke consumption will be through the use of prereduced ore in the charge. Thus, we will see the blast furnace gradually become converted to a gigantic cupola (melting furnace) whose output will be limited only by the ability of the cast house to handle the hot metal produced. Such operation will see further reduction of coke consumption down to as little as one-half of the lowest consumption per ton of hot metal realized today. This will come about by the use of large quantities of directly reduced iron ore produced in large-scale direct reduction operations carried out in those areas in the world blessed with the combination of iron ore (either high or low grade) and low cost fuels, i.e., natural gas, petroleum derivatives, or non-coking coals.

Iron Ore and Scrap

14. Iron units are consumed by the steel industry in three basic forms--iron ore, scrap, and pig iron. Iron ore and scrap are by far the most important in international trade.

15. While the major steelmaking centers of the world (United States, Europe, U.S.S.R., Japan, and the United Kingdom) were originally based upon abundant quantities of local ores, several, notably Japan, Europe, and the United Kingdom, are no longer entirely self-sufficient with respect to iron ore. As a result, there is a growing international trade in iron ore.

16. The world's steel industry is currently consuming about 500 million metric tons per year of iron ore. Of this amount, over 85 million tons per year of iron ore is involved in international trade (consider the ECSC as a single entity). In general, the major steelmaking centers still supply over 75% of their requirements from local sources. However, many of these local ores are relatively low grade and, with the resulting high slag volume, costly to reduce. Generally, imported ores are of the very highest grade.

17. With the anticipated growth in world steel production, it is inevitable that the major steel producing centers will import more and more raw materials. UN projections through 1975, extended through 1990 using generally the same basic projection method, indicate that annual steel production will increase from the present 399 million net tons (1961) to about 1220 million net tons (1990). This means that the annual consumption of iron ore will increase from the present 500 million metric tons (1961) to 1600 million metric tons (1990).

18. There is no question as to the adequacy of ore reserves throughout the world which have been estimated at 165 billion metric tons of exploitable, geologically explored iron ore reserves. However, by this time, the iron ore to feed this industry will come from many new mines and an increasing proportion of this iron bearing material will come from overseas via large, bulk, oceangoing ore carriers. The need to upgrade some portion of this vast tonnage to save transportation costs will become more pressing.

19. It is clear that there will be increasing competition between ore producers to supply the market. Increased competition has been evident even in the last several years, taking the form of price cutting, upgrading, and physical beneficiation to supply the very highest grade raw materials to the industry. North American ore producers are all going into production of pellets in order to sell the ore. The trend towards higher and higher grade iron-bearing raw materials will continue and the most logical next step is prereduction at, or close to, the mine.

20. Directly reduced iron ore would contain 90% iron and would be considered synthetic scrap, or melting stock. Thus, it would have to compete with scrap. What then is the situation in the world's steel industry with respect to scrap?

21. It is difficult to estimate the total annual volume of scrap consumed by the world's steel industry because much of it is derived from internal (in-plant recycle) and local sources. The availability of scrap in the various steelmaking centers depends in part on the steelmaking practice in use there. For example, in certain parts of Europe where the Bessemer or Thomas converters are the dominant steelmaking practice, scrap is abundant because these air-blown converters cannot consume much scrap. Conversely, in southern Europe where the open hearth process is the dominant steelmaking practice, scrap is scarce because the open hearth consumes large amounts of scrap, normally about 40-50 per cent of the charge.

22. Generally speaking, scrap is abundant only in the highly industrialized nations of the world and there is a growing international trade in the iron and steel scrap. If we consider the ECSC as a single entity, the international trade in scrap is about 7 million long tons per year. Of this amount, about 70% originates from the U. S. This is a good indication of the limited tonnages of scrap available for international trade. The ECSC and Japan are the major importing entities; the former accounts for about 40% and the latter about 30% of the total scrap imported.

23. Scrap is sold throughout the free world on a basis of "what the traffic will bear." Steelmakers have been plagued with widely varying scrap prices; high when steel production was up and demand was high, and low when steel production rates dropped. With the growth of oxygen steelmaking the demand for scrap will probably ease and prices will become more stable. At the present time scrap in the United States is at a near record low with prices at $20-$25 per ton. Prices will probably not go below this level as one could not justify the collection, preparation, and distribution costs.

The Forthcoming Revolution in Direct Reduction

24. The sweeping changes which we visualize in the world steel industry over the next twenty years will have as their foundation the rapidly accelerating science and technology of our times.

25. Technological innovations in direct reduction methods are being made in many of the Western nations. Work in this field has one aspect which is of particular interest to this conference. Most technical assistance to the less developed areas

involves the transfer of technology which has been applied for some time by the highly industrialized nations. In the case of direct reduction we have an example of new research and development which will first be applied in most cases by the less developed nations. In general, these new developments entail improved flexibility in handling very large, as well as small tonnages of ore per day, improved methods of generating reducing gases from natural gas and petroleum products, and better means of beneficiating and compacting the final product.

26. A partial list of the more recent direct reduction processes is presented in Table 1. One reason for the large number of proposed approaches to direct reduction is that no one process is best for all applications. Variations in local raw materials characteristics, local costs, size of operation required, and other factors will dictate the final process choice.

27. It is not possible in this paper to describe these processes in detail. However, such information can be obtained from the references as noted. In general, the processes can be broadly classified in two categories: those that employ gaseous reductants derived from natural gas or petroleum deposits, and those that employ solid fuels, usually non-coking coals or coke fines. A brief description follows of each category of process.

28. A typical gaseous reduction process involves as a first step the formation of a suitable reducing gas, such as a mixture of carbon monoxide and hydrogen from natural gas or fuel oil. This gas, heated to about 850 C, is then blown through a series of three fluidized bed reactors countercurrent to properly screened iron ore which is fed in the top of the first reactor and passes downward by gravity through the system. The fluidized bed reactors are capable of handling large tonnages of material continuously with excellent efficiency of gas utilization. The reduced iron product can be utilized directly or agglomerated for use as melting stock in various types of furnaces as shown in Figure I. If low grade iron ore is fed to the process the product can be beneficiated by grinding and magnetic separation. The flexibility of both process and product is evident. A variation on this process involves a batch process utilizing fixed bed rather than fluidized reactors.

29. Other points about this process are worthy of mention. Undesirable impurities in the iron ore, such as titanium and phosphorous, can be removed under certain conditions. In addition, it is possible to use direct reduction in combination with magnetic separation and further chemical processing to extract such materials as aluminum, manganese, nickel, chromium, etc. from iron-bearing ores which might not otherwise be feasible to treat economically. This could be of great interest in certain parts of the world.

30. The solid fuels direct reduction process steps are similar to the gaseous fuel method just described with the exception that a large, rotary kiln type reactor is usually employed, and any unburned coal or coke is recycled after magnetic separation through the kiln. The temperature of the kiln is carefully controlled by suitable gas or fuel oil burners located along its length.

31. The products of both general process categories are similar and can ordinarily be controlled to a range of 80 to 95 per cent iron, depending on the economics as dictated by product market. Agglomeration of the product is controlled to produce sizes best suited to end use. For iron blast furnace feed this would be small pellets and for synthetic scrap for steelmaking furnaces, larger briquettes.

The Economics of Direct Reduction

32. A modern blast furnace plant, the conventional method of iron ore reduction, involves an investment of approximately $75 per annual ton of pig iron capacity.

Thus, a 1,000,000 ton per year blast furnace (2) plant together with required coke plant facilities, requires an investment of about $75,000,000. The investment requirements of direct reduction plants of equal capacity are approximately $56 per annual ton for HyL; $67 for H-Iron; $49 for ADL; and $45 for R-N. Thus, a 1,000,000 ton per year direct reduction plant would involve an investment of $45,000,000-$67,000,000, or a saving of 10-40 per cent over the blast furnace.

33. The cost of producing melting stock via these direct reduction processes varies from about $18 to $25 per ton based on fuel valued at 20 cents per million BTU's and ore costs at market, or $6 to $9 per ton, and labor costs of $1.60 per hour. While the range of these costs is large, they can be estimated quite accurately for a particular situation where raw materials, labor, etc. component costs are known. This range of costs compares with pig iron costs of $40-$50 per ton from the blast furnace. These figures are not entirely comparable since the blast furnace produces molten pig iron, whereas the direct reduction product is ordinarily a cold melting stock of very high purity. Thus, it is more logical to evaluate this melting stock by comparing it with the price of scrap or the value of beneficiated iron ore. The price of scrap in the United States is ordinarily about $30-$35 per ton. Direct reduced melting stock might attain a higher value as it is lower in metallic impurities, is more constant in composition, and better sized to suit end use. The evaluation of direct reduced melting stock as a blast furnace or hot blast cupola feed material is a more difficult task. Here one will require experience in order to set prices. Two observations can be made at this time. First, utilizing about ten per cent melting stock (90% Fe) in a blast furnace charge, calculations show a $2.00 per ton saving in hot metal cost when the melting stock is priced conservatively high at $41 per ton. The savings come about because of lower coke and limestone consumption and increased hot metal output. One can easily visualize slowly converting the blast furnace into a giant cupola as the trend is continued toward feeding higher and higher percentages of melting stock. Second, direct reduced melting stock has been stated on the basis of experience to date to be valued above scrap as a hot blast cupola charge because of the absence of metallic impurities. Thus, it appears that the largest future market for direct reduced melting stock will be in supplying the major steel centers of the world with upgraded raw material for the blast furnace or hot blast cupola feed to produce hot metal, and to a lesser extent as synthetic scrap for use in feeding steelmaking furnaces.

34. The advantage of carrying out the reduction step near the mine site in order to save shipping weight is obvious. Those nations blessed with both iron ore and inexpensive fuel are in a position to supply the steel centers of the world with very large tonnages of superior iron-bearing raw materials. Such operations would utilize local fuels, such as natural gas, which might otherwise not be used for many years. In a sense, one could say that direct reduction would provide a means of exporting fuel and would raise the value of the ore exported from about $6-$9 per ton to about $25-$35 per ton.

Small Local Steel Plants

35. The per capita consumption of steel today in most less developed areas seldom exceeds 20 pounds per year. This means that requirements for small local steel mills would begin in the range of 40,000 to 200,000 tons per year. Nevertheless, with the projected expansion in world steel requirements previously mentioned, we visualize a substantial increase in production in countries not now producing steel. This production will probably reach about 100,000,000 tons per year by 1990. Since a conventional blast furnace and steel plant can seldom be justified at less than 1,000,000 tons per year capacity, the answer must be found by another route. World trade in scrap is so limited in tonnage that small steel plants based on scrap will not provide the answer. Thus, we turn to direct reduction.

36. There are several bases upon which small steel plants may be justified in the less developed areas. If costs of fuels and raw materials are low enough, this alone might permit straight economic justification even at relatively small scale. A small steel plant might be made economical by operating on a fractional portion of the product from a large scale direct reduction operation supplying melting stock to the world market. In this case, the small melting, casting, and rolling operations would benefit from the improved economics of the large scale reduction operations. If large quantities of directly reduced synthetic scrap were available at moderate prices, this might also justify small local mills in those areas not blessed with iron ore. If the political atmosphere is such that added employment, independent supply, savings in foreign exchange, etc. would override in importance strict economics, small mills will be justified and built.

37. The local steel plant would consist of a direct reduction unit scaled down to proper sizes to meet requirements. Fortunately, many of the direct reduction processes can be scaled down and yet operate efficiently. The product from the reactors would be fed to a steelmaking furnace, probably electric, and the steel cast into billet-sized ingot molds or continuously cast to avoid the high cost of a primary breakdown mill. The billets would then be fed directly to the rolling mill.

38. A plant of this type would cost about $8,000,000 for 40,000 tons per year capacity and $28,000,000 for 200,000 tons per year capacity. It could supply many of the less expensive, easiest to produce types of steels and steel products normally required by the less developed areas. The typical consumption pattern for these areas is as follows:

Product	% of Total Consumption
Reinforcing Rods	30
Rounds	10
Light Structurals	7
Wire	10
Total Merchant Products	57
Sheet and Plate	12
Galvanized Sheet	5
Tinplate	7
Total Flat Products	24
Pipes and Tubes	12
Miscellaneous (Primarily Rails)	7

39. The merchant products, including bars, rounds, light structurals and wire, could be produced in a small merchant mill supplemented by wire drawing equipment. In addition, some skelp for pipe and tubes might be produced. More sophisticated steel products which represent only about 40 per cent of requirements would still have to be imported.

40. Capital and operating costs for such mills can be estimated quite accurately when local cost figures are provided. In the absence of such figures, we estimate the common merchant mill products could be produced in the range of $90 to $110 per ton.

The Future

41. By 1990 world production of steel is expected to increase threefold. There is opportunity for many of the less developed areas of the world to participate actively in this growth through the utilization of direct reduction.

42. The additional supply of iron units required for the expansion of steel production must come from iron ore. Tonnage supplies of scrap are limited. Iron is one of the most abundant and widely distributed elements in the earth's crust, representing about 4 percent of the total. Its supply is essentially limitless in almost all regions of the world. The areas of the world where natural gas and oil deposits, the major fuels for direct reduction, are known, are numerous and are expected to increase. Thus, opportunities to participate in the production of prereduced iron ore for world trade and small steel plants are legion. Among the many nations faced with this challenge are Algeria, Argentina, Brazil, Burma, Canada, Colombia, Egypt, India, Indonesia, Iran, Israel, Liberia, Mexico, Morocco, Pakistan, Peru, Thailand, Trinidad, Turkey, Tunisia, and Venezuela.

43. A new dimension is being added to our potential for steel production and it is up to all of us to understand its significance and possible application in the forward movement of our civilization now and in the future.

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TABLE 1 - THE NEWER DIRECT-REDUCTION PROCESSES

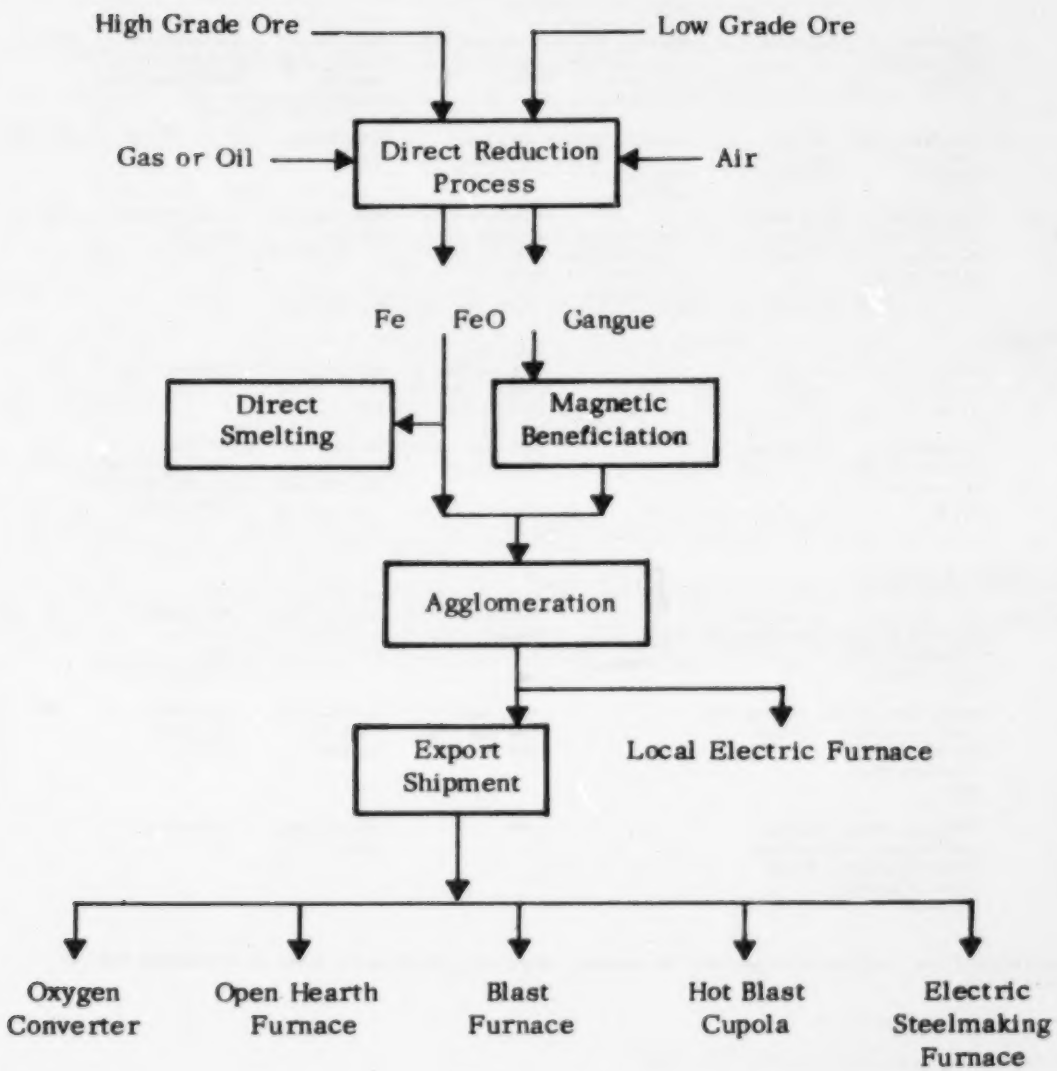
Process Name	Type of Equipment	Reductant (*)	Reductant Produced How	Ore	Final Product	Developer, Licensee, Etc.	Reference
Gaseous Processes							
HyL	fixed-bed reactor	hydrogen, carbon monoxide	catalytic steam reforming of nat. gas	rich lump ore, pellets: up to 1¼", max 20% - ¼ in.	sponge iron, 85% reduced	Hojalata y Lamina, M.W. Kellogg Co.	(1) (2)
H-Iron	fluidized-bed reactor 3-stage	hydrogen	partial oxidation, water-gas shift, scrubbing	hi-grade mag. conc'e mill-scale	low-C iron powder, 98% reduced briquet'd	Hydrocarbon Research Inc.; Bethlehem Steel	(2)
A.D.L.	fluidized-bed reactor, 3-stage	carbon monoxide, hydrogen	partial oxidation of nat. gas or oil with air	various, 1/8 in.	briquettes, 85% red.	A. D. Little, Inc.	(2) (3) (4)
ACAR (Allis Chalmers)	traveling grate, dual concetric kiln-within-kiln	hydrogen, carbon monoxide	cracking of hydrocarbons w. steam or air within kiln	hi-grade conc. pellets 1/2-3/4 in. diameter	iron pellets 81% Fe	Allis-Chalmers Mfg. Co.	(5)
Kiln Processes							
Freeman	rotary kiln, co-current fired	solid carbon fines		mag. or hem. conc's, 1/2-1 in. pellets	sponge pellets, 91.5% Fe*	Freeman Corp.	(6)
R-H	rotary kiln, countercurrent & internally fired	solid carbon fines		various, -1 in. + 20 mesh	briquettes or sponge, abt 90% red.	R-H Corp. (Nat. Lead Co. and Republic Steel Corp.)	(7)
Electric Furnace Processes							
Strategic-Udy	rotary kiln, countercurrent-fired, & electric furnace	solid carbon fines	. . . . .	various, -3/8 inch	molten iron 1-2.5% C	Strategic Mat'ls. Corp., Koppers Co.	(2) (8)
Ocarb	preheating kiln, balling drum, rotary kiln, electric furnace	coking coal fines	. . . . .	mag. conc's low P&S, 50%-100 mesh	molten pig iron-2% carbon	Swindell-Dressler Corp.	(9)
Dwight-Lloyd McWane	"Flying Saucer" pelletizer, D-L sintering machine, electric furnace	solid carbon fines	. . . . .	**	molten pig iron	McDowell Co.	

* "Solid carbon fines" indicates in general coke breeze, char, etc., anthracite fines or bituminous coal of subcoking grade.

** Not specified in literature.

General references: (10), (11), (12), (13), (14)

FIGURE I - POSSIBLE DIRECTLY REDUCED PRODUCT



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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.7.3

United States of America

THE DIRECT REDUCTION OF IRON AND THE LESS DEVELOPED AREAS

By Bruce S. OLD,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors (See notes overleaf.)

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THE DIRECT REDUCTION OF IRON AND THE LESS DEVELOPED AREAS

Bruce S. Old, Senior Vice-President
Richard W. Hyde and Edward L. Pepper
Arthur D. Little, Inc., Cambridge, Massachusetts

1. Revolutionary changes will take place in the world steel industry in the near future in terms of world iron ore trade and through the construction of numerous small steel plants. Both of these changes will have their major impact on the less developed areas of the world. New technology will permit low capital investment direct reduction operations to be carried out economically and world trade in directly reduced iron ore will become practical. The rising tide of nationalism will result in the establishment of small local steel plants based upon directly reduced iron ore.

2. Iron units are consumed by the steel industry in 3 basic forms--iron ore, scrap and pig iron. The two most important in international trade are iron ore and scrap. The world steel industry consumes 500 million tons per year of ore, over 85 million tons is involved in international trade, considering ECSC as a single entity. With the expected tripling of steel demand by 1990, iron ore requirements will probably reach 1600 million tons per year. Scrap is abundant only in highly industrialized nations, and its availability is limited to a few million tons per year. It is not practical to base a country's steel industry upon a raw material so limited in supply.

3. A modern blast furnace plant, the conventional method for reducing iron ore, involves an investment of $75 per annual ton of capacity and the minimum economic sized unit would produce 1,000,000 tons per year. Investment requirements for direct reduction plants of equal capacity are in the range of $45 to $65 per annual ton. The cost of producing melting stock via direct reduction varies from $18 to $25 per ton compared with pig iron costs of $40 to $50 per ton from the blast furnace. Melting stock can be compared with scrap--its value is less than molten pig iron--ordinarily at least $30 to $35 per ton f.o.b. source country--typically the United States. Utilization of directly reduced melting stock in the blast furnace would reduce blast furnace costs by decreasing coke requirements and increasing hot metal output. The advantage of carrying out the reduction near the mine is that it provides a means of exporting fuel and increases the value of ore from $6 to $9 per ton range to $25 to $35 per ton.

4. There are a number of direct reduction processes available. In general, these can be broadly classified into two categories--those that employ gaseous reductants derived from natural gas or petroleum deposits and those that employ solid fuels, usually noncoking coals or coke fines. A typical gaseous reduction process involves formation of suitable reducing gas from natural gas or fuel oil. This gas is heated blown through fluidized bed reactors counter-current to iron ore. The fluidized bed reactors are capable of handling large tonnages of ore continuously with high gas utilization efficiency.

5. The solid fuels direct reduction processes involve reduction in a rotary kiln type reactor of a mixture of solid fuel and ore. The kiln temperature is controlled by suitable fuel burners along its length.

6. The products of both general process categories are similar and typically contain 80 to 95% iron, depending upon the economics and dictates of the product market. The product can be agglomerated to appropriate sizes for shipment and for further iron or steelmaking.

7. Small steel plants will be justified in the less developed areas on several bases, both economic and political. These mills will require either scrap or a synthetic scrap raw material. World scrap resources are too limited, thus direct reduction will provide the material for such mills. A small steel plant could operate on a fractional portion of the product from a large scale direct reduction operation supplying melting stock to world markets or if local raw materials were not available a small local mill could purchase the necessary synthetic scrap from countries with large scale direct reduction operations. Such small mills would save foreign exchange, provide employment, create new industry, etc.

8. The small local steel markets could consist of a small direct reduction unit scaled to meet the individual plant's requirements as many of the direct reduction processes can be scaled down and yet operate efficiently. The directly reduced product would be melted in steelmaking furnaces, probably electric, cast into billets or continuously cast and then fed directly to a merchant rolling mill capable of producing perhaps 60% of the less developed country's requirements for steel.

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Agenda Item: D.1.3

United States of America

PLANNING MANAGEMENT DEVELOPMENT IN INDUSTRIALIZING COUNTRIES

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PLANNING MANAGEMENT DEVELOPMENT IN INDUSTRIALIZING COUNTRIES

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1. The whole process of rapid industrialization of a country can succeed only when and if there are adequate numbers of effective managers to manage that industrialization. The prime requirement of every effective plan from the national level down to the individual corporate level is for able professional managers who are trained to analyze complex economic, social, and political situations; to make decisions; and to follow them up. Lack of the required numbers and quality of managerial talent is, in most cases, the prime cause of failure or retardation of a plan of development. Moreover, expatriate talent at the managerial level is a temporary solution at best.

2. It is the thesis of this paper that such indigenous management development must be planned, that it must largely be based on indigenous institutions, and that help and support given by more advanced industrial countries must be carefully integrated into a total plan or it may be actually more harmful than helpful.

3. There is a case for unplanned management development just as there is for unplanned leadership development in other areas, but the unplanned case is a poor one and can be disastrous to a country seeking development. The two major reasons for this have been mentioned elsewhere.[1] First, unplanned methods will not produce the numbers required. Second, there is strong evidence that old methods and old mistakes inappropriate to rapid development are perpetuated and become more firmly entrenched if new approaches and new ideas are not interjected. A third reason, however, has not been stressed. It is that the opportunities of a rapidly developing society often create inappropriate styles of business leadership. The quick gain available to the ready few would be less possible if there were available and ready large numbers of well-trained managers, competitive and willing to compete, and, hence, less open to temptation. A case can be made that public dismay and disillusionment with the performance of a public sector or private sector management can often be traced to the overwhelming opportunity for wealth available to the few who are prepared to manage and the absence of reasonable numbers from which to select leadership.

4. The difficulties of constructing several patterns of planned management development are many. Precisely because new patterns of human activity must be quickly established, there is often a conflict with existing patterns of culture and social norms. This is true to a much greater extent in the management development case than if technical skills alone were involved. For example, the entrepreneurial function may not be a fully acceptable pattern or may be reserved to certain groups only. Again, a long-established practice of administration that calls for methodological

[1] See, for example, Myers, Charles A., and Harbison, Frederick, Management in the Industrial World, McGraw-Hill Book Co., Inc., New York (1959)

but unimaginative applications of routines may inhibit broader vision and action. Another illustration may lie in those situations where the selection of individuals for business leadership roles is done on a narrow or highly restrictive basis. Most of all, a long-established narrow concept of organization may restrict decision-making of any import to the very top to the frequent accompaniment of apathy and non-involvement below. In short, to discuss management style and its development apart from dealing with the environment is not to deal with the management development problem at all.

5. It is this linkage between management environment that confronts us in the proposition that all or a major part of managerial training can be done in foreign institutions. It will be argued here that it is dangerous to rely primarily on such outside development. This is not to say that an important contribution cannot be made by foreign training placement. It can, of course, and has, in two important ways. First, foreign training placements can be used as they have for many years, to provide basic training for outstanding young men. It is estimated that the foreign student enrollment in the leading American business schools ranges from 8 to 15 per cent. The problem of the young man's return or "re-entry," however, is not uncommon. Often after a lengthy period, let us say 2 to 5 years, the man may have accepted the assumptions of a foreign environment so completely that he is unable or unwilling to make the translation to his own ground. At the superficial level, this may be only a case of vocabulary and form as, for example, the young man who returned to his own country after two years of advanced economic training. He gave a lecture on development economics to a group of senior civil servants, frequently using the terms "input" and "output." After the lecture, one senior civil servant asked a colleague, "What are these 'in and out things,' and where should we put them?", and promptly dismissed the possibility of communicating with the young man. But such vocabulary superficialities, vexing as they may be, are not as serious as the acceptance of new assumptions and relationships within the society that may not be present in the home ground. The well-organized education in management in a foreign environment can be helpful in avoiding these problems if the following conditions are met:

(a) Careful selection of the man

(b) Effective placement in a sufficiently demanding institution

(c) Continued contact with the home environment

(d) Placement and follow-up on the man's progress upon his return.

These conditions can be more effectively met if there are dynamic vehicles for training and education in the man's own country.

6. I turn now, however, to the second important contribution to be made by foreign training. It is in building awareness and stimulating thought along new lines among more experienced managers. This has been a successful pattern in the past. I would argue, however, that substantial improvement and effectiveness of these experiences can be achieved by organizing a program of study and application rather than merely visit or tour. In short, education takes place here as elsewhere only when a vigorous confrontation of ideas takes place, and this may not be possible in passive observation. Under the general heading of stimulation, I will include short courses in foreign countries, the foreign study tours, and the special task forces of various kinds.

7. I have sketched the two major avenues of foreign training. I have argued that while useful, these avenues are inadequate for meeting the total management needs of their countries largely because the home environment is not taken well enough into account, and even where it can be, the numbers potentially trainable in foreign situations will become increasingly inadequate to meet the needs envisioned. In short, this valuable foreign training vehicle must be well used as an ancillary vehicle

rather than the principal base for planned management development. How, then, should the outside resource contribute to the development of managers? Essentially the outside source should serve as a consultant or specialized resource and always as a part of an over-all plan in which the basic administration of the program is the responsibility of the country involved. The involvement of personnel from outside the country will probably be critical to the success of a total development plan, but the requirement must always be that these personnel are fully qualified. Second-rate talent, either because of lacking technical or psychological qualifications simply will not be able to make the contribution required. This raises a major problem, of course, for the contributing country. The problem of attracting high-grade foreign talent to help in the development of local institutions and individuals is the most severe restriction facing the developing country. If it can be solved, the several problems of developing institutional arrangements within the country are open to solution. Possible areas of collaboration are described below.

8. Planning for Institutional Development. Important participation in the planning process for developing managers may come from university sources, from government, and from private industry. It is probable that separate operations and their arrangements by each of these sectors of the life of a country can contribute in their own special ways. Of principal importance is the real interest of the top policy makers in each of these sectors in the education of managers. Lack of interest or a superficial concern at the top in this or other aspects of planning in general are sure retardants to the effectiveness of the program. To this planning function, the assistance of foreign educators, businessmen, and administrators can be useful. In analyzing the need for education and training, special contributions can be made, for example, in the following general areas.

9. The Levels of Education and Training Required. There are at least three age levels of development that may be appropriately considered in the design of a program for educating management. The first level of business education may be described as the preparation of the group of men and women who are entering the world of administration for the first time. These are young people in their late teens and early twenties who need a solid preparation in one broad field: The arts, engineering, science, and who need, in addition, a reasonable understanding of economics, psychology, mathematical analysis, and the inter-mix of business fields - finance, marketing, and production. Note that I am not talking about the preparation of clerks, routine analysts, bookkeepers, and other office personnel. Presumably, these occupations will continue to require personnel in the realm of administration. But the present avenues of preparation for these fields are already over-expanded in most less developed countries and only rarely does this preparation aid substantially in preparing managers who can create and guide new and growing institutions. Note also that I would tend to omit from the curriculum of these entrants to administration detail in such important specialties as methods improvement and salesmanship. There is a growing feeling in the United States that these specializations and details are better left to practice and early training in business itself. The problem, then, at the entrant stage, is to prepare these men to think soundly about complex business problems. This implies also that persons selected for this education are well chosen - that they are bright, are well motivated, and demonstrate an interest in leadership.

10. In connection with this entire program of primary education in management is a question of what institution should be responsible for this educational function. The appropriate answer is the university, providing the university is willing to produce a level of professional education which at its best can be likened to other professional schools in the university such as law and medicine. If this is not possible, other institutions for business and management education will have to be improvised. In any case, the active involvement of foreign consultants, not as directors, but as advisors

and participants, can be useful. A direct link with a foreign group can be exceedingly helpful as a continuous vehicle for interchange of ideas and personnel.

11. The second level of this administrative education can be termed the middle management level. There are several goals to be accomplished in this category. We are concerned here typically with advancing the man whose early training prepared him for a specialty, who by experience and accomplishment has expanded his scope of operations, and who has become a manager in name if not in fact. He needs basic help in broadening his base of understanding. Often he was trained originally as an engineer, yet now his decisions are primarily market and finance based. Again, he may be the small operator whose success now finds him with fifty or more employees. His effectiveness is now judged, not in terms of his individual craftsmanship or ability to work, but on his ability to manage. Finally, there is the man who needs to be brought up to date in new fields and old, and who needs the stimulation of ideas of others. For all these reasons, after-hours courses or clinics, short courses, and conceivably longer ones, are valuable. In a way, these types of courses offer the most immediate pay-off, because progress made by the individual is immediately translated into practice. No one institution is singularly equipped here. University and government sponsorship has proven effective, and so have management associations and individual company schools. In all cases, the full involvement of foreign teachers and advisors is useful. It is a lamentable fact, but fact none the less, that at these levels, the visiting consultant is often given greater credence and greater authority than is a local expert. A combination of faculty members, with the end in view always to grow out of the reliance on foreign faculty, is probably a reasonable goal.

12. The final level that involves still other dimensions of need and response is the advanced management or policy level course. Here the goal is to deal at the highest possible level of organization, and in developing the modern management approach of these already proven men, to have an influence directly on the shape of delegation and command within organizations. All of the previous purposes of proving training opportunities for other levels are present here also, but the goal of changing attitudes toward styles of administrative organization gives this level of program special importance in developing countries. The program format can vary from the long weekend to six weeks' residence programs. Here, especially, competent faculty, acceptable to the participants, is a requirement. For this reason, there is some advantage to using a foreign faculty, providing the over-all framework of the program is seen as an indigenous one and providing once again the direction is one of transference to local institutions. Symbolically, as well as functionally, such a program can be among the most important of the management development efforts of a country. It permits highly placed and highly competent administrators, both public and private, to get together in serious efforts at self-improvement. It encourages directly the development of whole organizations because it deals with the top, a requirement of any further improvement.

13. Methods. This is no place for a complete discussion of the most appropriate methodology in management development except to stress that the methods used must be not only effective pedagogically in the foreign country from which they are taken, but must be adaptable and congruent with styles and terminology in the developing country. Indeed, research in teaching methods and materials should be a prime requirement in the developing institution. The wholesale adoption of materials from other countries produces a kind of barren dialogue that may actually deter creative thinking. There is great opportunity here for innovation in teaching and learning methods. Many new ideas can come from without, given appropriate assistance, but the emphasis should be on local involvement and local responsibility.

14. Standards. There is need to stress in this field perhaps more than most, the need for enforcing standards of faculty selection, student selection, and performance

reviews of both. Commerce schools have a distressing habit of placing last in the list as a talent magnet for young students and, indeed, for faculty. Part of the answer lies in the spectrum of needs served by such schools, and that is all well and good. But at the management end of the spectrum, special care must be taken to enforce high standards. For this reason, tests for admission, and a critical weeding out of the unfit is a probable requirement in a new institution. At the teaching level, faculty members must meet qualification requirements for both business and academics.

15. Here again, the involvement of assistance from outside the country can be appropriate. Long-term assistance in this problem seems useful, since the question of raising standards involves the development of a faculty discussed below.

16. The Development of Faculties. The heart of any academic institution is its faculty, and yet an "Operations Bootstrap" is difficult to achieve on the part of a new institution by itself. Younger faculty members, chosen and developed by older fixed faculty, are seldom likely to go beyond the bounds of their masters. A multi-university system has advantages in this sense in discouraging inbreeding. Since such a system is probably not feasible in a developing country, it is here that the relationship between foreign country resources and the developing country may be closest. With places for students at a premium, it seems reasonable to put a high priority for advanced education in foreign countries on the faculty members of the developing country. These men will multiply their effect in the affairs of their own country beyond that of any single group. Ideally, situations should be developed where there is a frequent contact between the professor - student and a base in the foreign country. Over the years a sense of identification with a foreign base and a concern for their advanced students' progress on the part of a foreign faculty promises added advantage. The sense of these contacts should always be study-oriented and need not always be confined to the foreign university itself. Rather, the foreign university can be the base from which project travel and study can be arranged and coordinated. I would argue that such a work centered and long-term relationship offers the best opportunity for strong leverage in the development process.

17. Creating a Market for Graduates. One of the problems that cannot be overlooked in the design of a professional school is the problem of the placement of its graduates. The common situation often found in transitional countries is that of large numbers of educated unemployed, often in the midst of shortages of many key personnel. The problem here is a lack of contact of the supplying institution with the market or lack of information on the part of students, employers, or both. In part, the answer lies in more effective selection of the students initially and a more effective curriculum. In part, also, it will be necessary to create new habits of selection on the part of employers and a new willingness on the part of students to go where the work is available. All of these situations will require thought and planning, and outside institutional help can be helpful in providing experience and guidance.

Two Cases of Cooperative Effort in Management Development

18. I would like to describe two different kinds of cooperative effort in the development of management in developing countries. Neither is presented as a model. In fact, it will be seen that both could have been more effective. None the less, the over-all effort was one of fitting the design of the program to the objectives and needs of the countries in question, and as such may be instructive to others. The first is an effort at management development in India, the second in several countries in Africa.

19. In India, a great deal of attention has been given to problems of developing management. One aspect of the development has been the concern for advanced management programs at the very senior and policy levels of management. This is a difficult problem in any country, and in a developing one, it bids fair to defy solution. Lack

of time and interest of top people in organizations, unavailability of appropriate faculty, and lack of appropriate sponsorship are especially difficult in such situations. In 1959, the All India Management Association, with active cooperation from government agencies, entered discussions with the Ford Foundation and with M.I.T. to develop such an advanced management program. The participation of M.I.T.'s School of Industrial Management was arranged, and a series of meetings to design the curriculum and other aspects of the program format were begun. In 1960, the first of such short programs took place, involving 30 top Indian executives from both the public and private sectors, and 6 senior faculty members organized by M.I.T. for a 4-week period. The selection of executive participants was made by a Management Association committee with the aid of local management associations. Speakers and guests were invited by the Association. The curriculum included intensive discussions on business economics, corporate finance, business economic environment, human resources use, labor management relations and management organization. Discussions, cases, readings, and individual conferences were methods employed, but the prime quality of these sessions were the close relationships which developed among the participants and faculty members. Sessions of the program were continued in 1961 and 1962 for new groups of executives. In each case, great interest and enthusiasm were exhibited by both participants and faculty members. At the conclusion of these later programs, reunion conferences were held with the past participants in the program. A substantial number, over two thirds of the participants, attended these conferences, coming from all over India for the 3-day meetings. Evaluation of these reunion sessions indicates that the participants have made use of the ideas and concepts developed in the programs to a surprising degree. In the last session, two members of the faculty were Indians, and it is expected that the program faculty will be organized by an Indian institution within the next two years. This latter point demonstrates one of the problems involved in such a program - the transition from a foreign to a local country staff. In this case, the two new institutes of management developing in Calcutta and Ahmedabad represent obvious and appropriate channels for continuing this advanced management program.

20. In summary, this program is accomplishing the purposes of the advanced management program as described earlier. It was developed under the sponsorship of a local agency, it utilized the services and talents of a foreign institution, and steps are being taken to translate the staff to local organizations and sponsorship.

21. The second case involves the placement and employment of several highly trained younger specialists in economic development posts in Africa over the past three years. Here an M.I.T. professor, Carroll L. Wilson, explored the need for such young talent at the assistant secretary level with the new governments of several newly independent African countries. As a result, in 1960, eight young men under the sponsorship of the M.I.T. School of Industrial Management, with engineering and industrial education and experience, were placed in posts in ministries of finance, economic development and planning, commerce, and others. Each man was employed by his new government for a two-year period, with responsibilities, in addition to the other duties, of developing African replacements. In 1961 and 1962 larger groups of men were individually employed and placed by the same and other governments. At the present time, 26 men have served 8 countries for substantial periods of time. The evaluation of this program by its observers and the employers involved is that the young men have served remarkably in this period of transition. Their involvement in the governments in the countries has been substantial, important tasks have been delegated to them, and their performance has been judged outstanding. The work they have carried on and the acceptance they have received are interesting, but not the subject of this paper. For our purposes, the program demonstrates the key requirement of local sponsorship, close coordination and cooperation between the foreign agency and the local government, selection of highly qualified men and their careful placement, close supervision but major delegation of responsibility, and concern for the transition of the program to total African participation.

CONCLUSIONS

22. This paper has examined certain aspects of the problem of management development in industrializing countries. I have presented the case for planned development and have questioned the adequacy of solving this problem by reliance on foreign placement alone. The task of creating adequate local institutional framework for development is a formidable one. I have been especially concerned with the relationships between foreign agencies and those of the developing country. Although no standard solution is available for any situation, I have stated as principles the following:

a. The local program should be concerned with the development of several levels of management.

b. There is room and need for participation from universities and the private sector as well as government.

c. Attention must be given to the problem of the market for managers, both junior and senior.

d. All programs should have local sponsorship.

e. Foreign personnel participating in the programs must be of first-rate competence.

f. Early consideration must be given to the problem of process of transition from foreign faculties to the local faculty.

g. Long-term ties between a foreign educational base may well serve the objectives of the developing local institution.

23. Finally, it seems to me, that the newly developing countries must be expected to make a creative contribution to the developing science of management. There is an urgent need for new theory and practice in the field of management, and it is confining to assume that we face only the problem of transferring existing knowledge from one society to another. Indeed, we have to expect that the situations posed by rapid development offer outstanding opportunities for innovation not found in already industrialized countries. We need the creativity implicit in the challenges of the new societies in this field as well as in others.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.1.3

United States of America

PLANNING MANAGEMENT DEVELOPMENT IN INDUSTRIALIZING COUNTRIES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

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PLANNING MANAGEMENT DEVELOPMENT IN INDUSTRIALIZING COUNTRIES

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1. The whole process of rapid industrialization of a country can succeed only when and if there are adequate numbers of effective managers to manage that industrialization. The prime requirement of every effective plan from the national level down to the individual corporate level is for able professional managers who are trained to analyze complex economic, social, and political situations; to make decisions; and to follow them up. Lack of the required numbers and quality of managerial talent is, in most cases, the prime cause of failure or retardation of a plan of development. Moreover, expatriate talent at the managerial level is a temporary solution at best.

2. It is the thesis of this paper that such indigenous management development must be planned, that it must largely be based on indigenous institutions, and that help and support given by more advanced industrial countries must be carefully integrated into a total plan or it may be actually more harmful than helpful.

3. The case for unplanned management development is a poor one and can be disastrous to a country seeking development. The major reasons for this are, first, unplanned methods will not produce the numbers required, and, second, there is strong evidence that old methods and old mistakes inappropriate to rapid development are perpetuated and become more firmly entrenched if new approaches and new ideas are not interjected. Third, the opportunities of a rapidly developing society often create inappropriate styles of business leadership.

4. The difficulties of constructing patterns of planned management development, on the other hand, are many. Precisely because new patterns of human activity must be quickly established, there is often a conflict with existing patterns of culture and social norms. This is true to a much greater extent in the management development case than if technical skills alone were involved.

5. It is this linkage between management and environment that confronts us in the proposition that all or a major part of managerial training can be done in foreign institutions. Important contribution can be made by foreign training placement, of course. The well-organized education in management in a foreign environment can be helpful if the following conditions are met: (a) Careful selection of the men to be trained and educated; (b) Effective placement in a sufficiently demanding institution; (c) Continued contact with the home environment; (d) Placement and follow-up on the man's progress upon his return. These conditions can be more effectively met if there are dynamic vehicles for training and education in the man's own country.

6. However, the total management needs of their countries cannot be met in foreign placement because the home environment is not taken well enough into account, and even where it can be, the numbers potentially trainable in foreign situations will become increasingly inadequate to meet the needs envisioned. In short, this valuable foreign training vehicle must be well used as an ancillary vehicle rather than the principal base for planned management development. How, then, should the outside resource contribute to the development of managers?

7. Essentially, the outside source should serve as a consultant or specialized resource and always as a part of an over-all plan in which the basic administration of the program is the responsibility of the country involved. The involvement of personnel from outside the country will probably be critical to the success of a total development plan, but the requirement must always be that these personnel are fully qualified. Second-rate talent, either because of lacking technical or psychological qualifications, simply will not be able to make the contribution required. This raises a major problem, of course, for the contributing country. The problem of attracting high-grade foreign talent to help in the development of local institutions and individuals is the most severe restriction facing the developing country. If it can be solved, the several problems of developing institutional arrangements within the country are open to solution. Possible areas of collaboration are described in detail. They include planning for institutional development; developing programs of education for primary education in management, middle management, and top level management; developing new methods of education and criteria for appraisal of performance; developing faculties and creating a market for graduates of management programs.

8. Some general principles emerge from this discussion of the relationship between the foreign agency and the developing country. They are as follows: (1) The local program should be concerned with the development of several levels of management; (2) There is room and need for participation from universities and the private sector as well as government; (3) Attention must be given to the problem of the market for managers, both junior and senior; (4) All programs should have local sponsorship; (5) Foreign personnel participating in the programs must be of first-rate competence; (6) Early consideration must be given to the problem of process of transition from foreign faculties to the local faculty; (7) Long-term ties between a foreign educational base may well serve the objectives of the developing local institutions.

9. Finally, it seems to me that the newly developing countries must be expected to make a creative contribution to the developing science of management. There is an urgent need for new theory and practice in the field of management, and it is confining to assume that we face only the problem of transferring existing knowledge from one society to another. Indeed, we have to expect that the situations posed by rapid development offer outstanding opportunities for innovation not found in already industrialized countries. We need the creativity implicit in the challenges of the new societies in this field as well as in others.

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Point de l'ordre du jour : D.13

France

LE BETON PRECONTRAINT DANS LES REGIONS PEU DEVELOPPEES

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de la Précontrainte)

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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LE BETON PRECONTRAINT
DANS LES REGIONS PEU DEVELOPPEES

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l'Utilisation de la Précontrainte)

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1. DEFINITION SOMMAIRE DU BETON PRECONTRAINT

1,0 PRINCIPES GENERAUX

La naissance et le développement du béton précontraint sont dus aux travaux d'Eugène Freyssinet (1879-1962).

Au lieu d'armatures en acier doux ou mi-dur simplement noyées dans le béton qui caractérisent le béton armé traditionnel, dans le béton précontraint sont utilisés des aciers durs à haute limite élastique mis en tension à un taux voisin de cette limite. La tension des aciers est transmise au béton, qui se trouve ainsi comprimé. Les armatures tendues sont disposées de telle façon que les zones de béton comprimées soient justement celles qui subiront des contraintes de tension sous les charges d'exploitation de l'ouvrage. Cette compression préalable du béton par les armatures tendues (précontrainte) confère au béton des propriétés remarquables qui seront examinées plus loin.

Il existe deux manières de transmettre au béton la tension des armatures qui caractérisent les deux catégories fondamentales du béton précontraint.

1,1 PRECONTRAINTE APRES DURCISSEMENT DU BETON (POST-TENSION)

Les fils d'acier de 5 à 12 mm de diamètre sont assemblés en faisceaux ou câbles et placés à l'intérieur de gaines tubulaires en tôle mince qui les isolent du béton. Après coulage et durcissement du béton, des vérins hydrauliques sont fixés aux extrémités d'un câble et le câble est tendu par ces vérins qui prennent appui sur le béton. Les extrémités des câbles sont ensuite bloquées dans des ancrages spéciaux incorporés au béton, les vérins sont enlevés et l'espace libre entre le câble et la gaine est rempli avec du mortier de ciment injecté sous pression qui assure la protection de l'armature contre l'oxydation et rétablit l'adhérence. Cette méthode, qui ne nécessite aucune installation fixe, est employée pour les ouvrages construits sur place.

1,2 PRECONTRAINTE PAR FILS ADHERENTS (PRE-TENSION)

Les fils sont disposés parallèlement dans des coffrages et tendus en prenant appui sur deux massifs d'extrémité ancrés dans le sol. Après coulage et durcissement du béton, la tension des fils est relâchée. Les fils tendent à reprendre alors leur état initial, et l'effort qui a servi à les tendre se transmet par adhérence au béton qui, de ce fait, se trouve comprimé.

Ce procédé nécessite la construction d'installations fixes (massifs d'ancrage, aires de coulage etc.) et convient surtout à la fabrication d'éléments standard relativement légers produits en série dans des usines (poutrelles de planchers, éléments de couverture, poteaux, pieux, éléments de canaux d'irrigation etc.).

2. HISTORIQUE

Les premières réalisations (poteaux électriques, reprise en sous-oeuvre de la Gare Maritime du Havre) datent de 1933-1935. Elles ont été bientôt suivies d'applications importantes en Algérie (tuyaux à haute pression, barrage), en France (caissons dans le port de Brest) et en Allemagne (ponts de 34 m, poutres pour bâtiments).

Les premières années de l'après-guerre ont été marquées par la réalisation d'importants ouvrages en France (cinq grands ponts sur la Marne, Réservoirs d'Orléans, Nouvelle Gare Transatlantique du Havre) qui ont démontré les possibilités et les qualités du nouveau matériau et ont attiré de nombreux visiteurs étrangers. Depuis ce moment le béton précontraint a gagné rapidement un grand nombre de pays et son utilisation n'a cessé de s'étendre pour gagner tous les domaines de la construction, y compris celui de l'énergie nucléaire.

Son emploi est actuellement universellement admis et la plupart des pays a défini les règles de son utilisation. Le matériel nécessaire à sa mise en oeuvre et les méthodes d'exécution n'ont cessé de se perfectionner. Les aciéries produisent des aciers durs de qualité parfaitement adaptée aux besoins et leur production est en augmentation constante.

3. LES AVANTAGES ECONOMIQUES ET TECHNIQUES DU BETON PRECONTRAINT

3,0 HOMOGENEITE ET INFISSURABILITE

Le béton armé traditionnel est un matériau hétérogène car le béton des zones tendues des sections peut se fissurer sous les charges, les aciers seuls assurant alors la résistance. Dans le béton précontraint on se trouve en présence d'une décompression des zones tendues, préalablement comprimées, sans que les fissures puissent apparaître. Le matériau est homogène.

L'absence de fissures sous les charges procure une garantie remarquable contre l'oxydation des armatures. Cet avantage est important lorsqu'il s'agit d'ouvrages hydrauliques (surtout des réservoirs) et de constructions au bord de la mer.

3,1 SECURITE

La mise en précontrainte soumet le béton à des contraintes de compression et l'acier à des contraintes de tension qui ne seront jamais atteintes sous charges normales. Il s'agit là d'une épreuve préalable des ouvrages dans leur masse avant leur mise en exploitation. Un défaut de qualité du béton ou des aciers conduit à leur rupture, les réparations ou remplacements qui en résultent étant à la charge de l'entrepreneur. C'est une garantie de sécurité que ne donne aucun autre matériau.

3,2 ECONOMIE DE MATERIAUX

Le prix de l'acier dur pour béton précontraint, par exemple en France, est actuellement de 1200 NF la tonne, tandis que l'acier doux pour béton armé traditionnel coûte en moyenne 490 NF la tonne. Or, l'économie en poids réalisée grâce à l'emploi de l'acier dur est de l'ordre de 70 % pour les ponts. Il en résulte une marge de 26 % qui non seulement couvre les frais qu'exige la mise en oeuvre de la précontrainte, mais permet aussi de réaliser dans la majorité des cas des économies substantielles.

Les ouvrages en béton précontraint étant généralement réalisés en béton de qualité, une économie de l'ordre de 10 à 20 % est réalisée sur le volume de béton ce qui diminue d'autant le poids des structures et le prix des fondations.

Dans les régions peu développées ces économies de quantités de matériaux sont particulièrement sensibles à cause des frais de transport. L'acier, et bien souvent le ciment, sont des produits importés de loin par voie maritime. Ils doivent ensuite, dans la plupart des cas, être acheminés vers l'intérieur des terres, ce qui coûte d'autant plus cher que les routes sont mauvaises, les distances longues et les moyens de transport rares.

L'économie de matériaux conduit, dans les pays importateurs, à une économie de devises, surtout lorsqu'un ouvrage est construit en béton précontraint au lieu d'être construit en acier.

L'économie de matériaux est surtout importante pour les ouvrages de grande portée avec fortes surcharges.

3,3 ALLEGEMENT DE STRUCTURES

L'emploi de la précontrainte permet, avec une même hauteur disponible pour les poutres, d'atteindre des portées plus grandes. Cet avantage est important non seulement pour les ponts, mais aussi pour les bâtiments industriels où la technique moderne exige de grands espaces libres sans supports intermédiaires pour faciliter les manutentions et le logement de machines encombrantes.

3,4 ADAPTATION A LA PREFABRICATION

Le problème délicat de la construction en éléments préfabriqués est le joint entre éléments. Or, en béton précontraint l'exécution des joints est particulièrement aisée. Ils se trouvent précomprimés au même titre que les parties courantes et ne constituent plus des points faibles.

La méthode de précontrainte par fils adhérents (voir 1,2) est parfaitement adaptée à la production en usine d'éléments précontraints légers en grande série.

Parmi les avantages nombreux de la préfabrication nous insisterons sur l'économie de main d'oeuvre qualifiée.

4. REALISATIONS DANS LES PAYS PEU DEVELOPPES ET ANALYSE DES RESULTATS

4,0 NOTION DE PAYS PEU DEVELOPPE

Pour des raisons diverses, dans certains pays développés le béton précontraint n'a pas reçu autant d'applications que l'on aurait été en droit de prévoir. Par contre, certains pays moins développés sous d'autres rapports (nutrition, réseaux routiers, production industrielle etc.), tels que l'Inde et certains pays africains, ont su déceler très tôt le rôle que le béton précontraint était susceptible de jouer dans leur développement et l'on utilisé à leur profit. Leur exemple est particulièrement précieux pour la présente étude. Le développement du béton précontraint dans un pays ne correspond donc pas toujours au niveau de développement général de ce pays.

4,1 LES PONTS

Le béton précontraint convient tout particulièrement pour les ponts et c'est dans ce domaine qu'il a gagné le plus de terrain sur les autres modes de construction. En cas de grosses charges et de grandes portées qui caractérisent les ponts, les quantités d'acier utilisées, donc aussi les économies réalisées grâce à l'emploi de la précontrainte, sont importantes. Un gros avantage par rapport aux ponts métalliques, dont souvent on omet de tenir compte, est l'absence d'entretien (peinture périodique).

La préfabrication a été largement utilisée pour la construction des ponts dont les poutres peuvent être coulées sur le chantier et mises en place sur leurs appuis par des appareils de lancement ou des grues.

La mise en oeuvre du béton précontraint s'accomode bien aux méthodes de construction traditionnelles propres aux pays à faible équipement et main d'oeuvre abondante et bon marché (par exemple la fabrication et la mise en place du béton).

4,12 Ponts en Inde

Jusqu'en 1958 il a été construit en Inde 460 travées de ponts routes représentant une longueur totale de 18.000 mètres, et de nombreux ponts rails. Les ponts routes sur appuis simples ont le plus souvent une largeur de 6,00 m et une portée entre 30 et 45 m.

La raison qui a conduit à construire les ponts en béton précontraint était l'économie réalisée sur le prix des ouvrages. Il en a également résulté une importante économie de devises pour ce pays, importateur de l'acier. Les cônes d'ancrage pour câbles, qui étaient jusqu'à présent importés, sont maintenant fabriqués dans le pays. Cette fabrication se trouve justifiée par le volume de travaux. On a également commencé la fabrication de l'acier dur. L'Inde sera bientôt presque entièrement indépendante de l'étranger en ce qui concerne la construction en béton précontraint, les importations se réduisant à certain matériel spécialisé dont le prix est minime à côté du prix total des ouvrages.

Au début, la plupart des ouvrages étaient coulés sur place en suivant la technique du béton armé traditionnel. Actuellement on assiste de plus en plus au développement de la construction en poutres préfabriquées mises en place par appareils de lancement. Cette mécanisation s'avère économique même dans ce pays à main d'oeuvre bon marché. La construction en poutres préfabriquées présente en outre l'avantage de supprimer les échafaudages qui se trouvent en danger dans ce pays à crues violentes.

4,13 Ponts en Côte d'Ivoire

Une entreprise française a réalisé dans ce pays une vingtaine de ponts d'une longueur de 53 à 100 m, généralement à voie unique. L'entreprise a recherché au maximum l'économie de matériaux dont le transport à l'intérieur du pays est très onéreux en utilisant pour ces ponts des systèmes hyperstatiques. Ces ponts sont soit des systèmes à poutres continues, soit des ponts à béquilles inclinées permettant de réaliser des encastrements de part et d'autre de la travée centrale. Les câbles de précontrainte, en petit nombre, courent sur toute la longueur du pont, ce qui permet de réduire le nombre de cônes d'ancrage et la durée des opérations de mise en tension.

Des résultats remarquables ont été obtenus grâce à l'activité d'une entreprise dynamique d'importance moyenne à laquelle les services administratifs, compétents ont laissé la liberté d'action nécessaire. La construction d'un pont demande la présence d'un conducteur de travaux européens assisté d'une équipe d'ouvriers indigènes habitués au travail et attachés à l'entreprise, les manoeuvres étant recrutés dans les villages voisins.

4,14 Ponts à Madagascar

Une entreprise a construit à Madagascar une quarantaine de travées de ponts avec portées variant de 15 à 30 mètres. Là encore la réalisation est due à l'initiative d'une entreprise qui a su tirer profit des économies de matériaux importantes dans un pays éloigné.

4,15 Grands ponts dans les pays africains d'expression française

Le pont d'Abidjan (Côte d'Ivoire) est un ouvrage remarquable d'une longueur de 372 m en 8 travées de 46,50 m constituées par un double caisson à l'intérieur duquel passe une double voie de chemin de fer. L'importance de cet ouvrage dépasse le cadre des problèmes courants des pays peu développés.

La construction du pont sur le Wouri à Douala (Cameroun) d'une longueur de 1,035 m avec 21 travées de 45 m a demandé un équipement important pour la fabrication des poutre constituant le tablier. La main d'oeuvre locale s'est parfaitement adaptée aux diverses opérations de préfabrication qui se répètent un grand nombre de fois et ne demandant pas de formation professionnelle.

Le pont sur le Niger à Goya-Malanville (Niger) d'une longueur de 455 m et le pont de Bamako sur le Niger (Soudan) d'une longueur de 861 m sont des exemples de ponts de grande longueur construits en poutres préfabriqués mises en place par une poutre métallique de lancement. Cette méthode de construction, devenue classique, convient particulièrement pour les ponts de grande longueur. Elle demande peu de main d'oeuvre qualifiée et des investissements en matériel facilitent amortissables, surtout en cas de réutilisation.

4,16 Conclusions d'ensemble pour les ponts

L'utilisation du béton précontraint pour la construction de ponts dans les régions peu développées a donné des résultats très satisfaisants et il y a lieu de prévoir qu'elle va encore progresser et contribuer plus encore au développement des voies de communication, condition du progrès dans tous les autres domaines.

4,2 LES TRAVAUX MARITIMES ET HYDRAULIQUES

En plus des avantages économiques, l'emploi du béton précontraint pour les travaux maritimes et hydrauliques présente l'avantage de conférer aux structures une longévité que l'on estime largement supérieure à celle des ouvrages en béton armé. L'absence de fissures assure une protection efficace des armatures contre l'oxydation qui est la principale cause de ruine souvent rapide des ouvrages à la mer en béton armé traditionnel.

Les principaux types d'ouvrages maritimes pour lesquels le béton précontraint a été utilisé sont :

- les tabliers pour murs de quais et appontements, dont la technique de construction s'apparente à celle des ponts;
- les caissons pour murs de quais, cales sèches, etc,;
- les piles de fondation formées d'éléments creux préfabriqués assemblés par précontrainte.

Des constructions en béton précontraint des types cités ci-dessus ont été réalisés dans les ports suivants : Bangkok (Thaïlande), Belawan (Indonésie), Bougie (Algérie), Karachi (Palistan), Oran (Algérie), Port-Etienne (Mauritanie), Saïgon (Viet-Nam), Sihanoukville (Cambodge).

Parmi les applications du béton précontraint aux autres ouvrages hydrauliques réalisés dans les régions peu développées nous signalerons plusieurs barrages en Algérie, dont le dernier en date, celui d'Erraguène sur l'Oued Djen-Djen, est particulièrement intéressant, le barrage de Sefid-Roud (Iran), la conduite à haute pression de grand diamètre (Kunu Syphon, en Inde).

4.3 PRODUITS PREFABRIQUES

L'installation d'une usine de fabrication de produits à fils adhérents suppose l'existence ou la création d'un marché suffisant autour de l'usine sans que le prix des produits soit grevé par des transports trop onéreux. Cette installation dépend en grande partie du réseau routier. Il apparaît donc que les pays peu développés soient, en règle générale, moins favorisés pour l'installation de telles usines, à moins qu'il n'existe un plan de construction capable d'absorber la production (développement urbain, construction de lignes électriques ou de chemins de fer, etc.). Il est donc normal que les usines de préfabrication se soient surtout développées dans les pays industrialisés (U.S.A., U.R.S.S., pays européens).

Il y a cependant un certain nombre d'exemples d'installation d'usines de préfabrication dans les pays peu développés. Les usines fabriquant des poutrelles de plancher et poutres ont été installées en Inde, à Thaïland, à Guatemala, à Costa-Rica. Des installations de fabrication de poteaux de traverses de chemin de fer ont été créées pour la réalisation de programmes donnés en Haute Volta, au Sénégal, au Cameroun, en Algérie.

Le développement de la production d'éléments à fils adhérents fabriqués en usine et le succès des installations existantes dans les régions peu développées portent à croire que d'autres installations peuvent suivre dans ces régions, à condition que les programmes le permettent et que le béton précontraint soit mis en concurrence avec les autres matériaux.

4,4 IRRIGATION

Les applications du béton précontraint à l'irrigation concernent la construction d'éléments préfabriqués pour canaux surélevés et les conduites à haute pression.

L'expérience a montré qu'il est possible de fabriquer économiquement en usine des éléments de canaux en forme d'auges que l'on pose à la grue sur des supports en béton armé préfabriqués. La précontrainte permet d'obtenir des éléments parfaitement étanches de très faible épaisseur. Une usine établie au Maroc a donné pleine satisfaction.

Des usines de fabrication de tuyaux à haute pression en béton précontraint destinés à l'irrigation et à l'alimentation de villes ont été installées en Algérie, en Tunisie, au Maroc, à Cuba, en Angola, en Mozambique. Il existe plusieurs systèmes de fabrication de tuyaux précontraints exploités par des sociétés spécialisées. L'installation d'une usine de tuyaux ne peut être envisagée que s'il y a un programme assez vaste pour son amortissement.

5. POSSIBILITES ET PERSPECTIVES D'AVENIR

5,1 DOMAINES D'APPLICATION NON EXPLOITES OU INSUFFISAMMENT EXPLOITES

Le béton précontraint, malgré son extension rapide, n'a encore gagné qu'une faible part du volume total de la construction. Il est encore loin d'atteindre le développement que ses avantages permettent d'espérer, particulièrement en pays peu développés.

Le pays où la part la plus importante du marché a été attribuée au béton précontraint est l'U.R.S.S. où le plan prévoit qu'en 1965, 25 % de constructions préfabriquées en béton seront précontraintes. Une part assez importante du marché revient au précontraint au Japon, aux Etats Unis (préfabrication en usine), en Allemagne (ponts). C'est la France qui est intervenue le plus dans les applications en pays peu développés.

La raison principale qui retarde le développement du béton précontraint est la force d'inertie opposée par les autorités responsables, les bureaux d'études et les entreprises, qui très souvent ne font pas l'effort nécessaire pour assimiler une technique nouvelle et prendre la responsabilité de son application.

Les perspectives de développement en ce qui concerne les ponts, les travaux maritimes, la préfabrication en usine et l'irrigation résultent de ce qui a été au chapitre 4.

Il n'y a eu jusqu'à présent que peu de bâtiments construits en béton précontraint dans les régions peu développées. Cependant l'expérience montre que l'emploi du béton précontraint est avantageux dans les cas suivants :

- bâtiments industriels à grande portée et fortes surcharges,
- bâtiments d'usine importants dans lesquels on peut appliquer la construction en éléments préfabriqués sur chantier avec assemblage par précontrainte,
- couvertures en voiles minces de formes diverses et tirants,
- poutres et poutrelles ou dalles de planchers préfabriquées en usine pour bâtiments d'habitation.

L'application de la précontrainte aux bâtiments devra être envisagée dans les pays peu développés dans les cas suivants :

- création de centres industriels (bâtiments d'usines),
- construction de hangars (ports, aviation),
- programmes d'expansion de centres urbains (planchers).

Les réservoirs en béton précontraint sont rares dans les pays peu développés. Il a pourtant été constaté en France qu'à partir de 1000 m3 le prix des réservoirs précontraints est plus bas que celui des réservoirs en béton armé traditionnel. Les avantages techniques de la précontrainte (étanchéité) sont considérables et les réalisations nombreuses, notamment aux Etats-Unis et en Europe. La technique moderne de construction avec coffrages glissants s'applique très facilement aux réservoirs précontraints. Les applications couvrent les industries les plus diverses : distribution d'eau, épuration des eaux, hydrocarbures, sucre, cimenteries, industries chimiques etc.

5,2 CONDITIONS D'UN DEVELOPPEMENT RATIONNEL DU BETON PRECONTRAINT DANS LES REGIONS PEU DEVELOPPEES

5,20 Règlementation

La rédaction de règlements suppose une expérience théorique et pratique considérable que les pays, qui débutent dans une technique nouvelle, ne possèdent pas. Il est rationnel que de tels pays puissent adopter un règlement international existant. Un règlement issu de la Fédération Internationale de la Précontrainte, dont la rédaction est à l'étude, donnerait toutes les garanties de qualité et présenterait l'avantage d'éviter les clauses spécifiques d'un règlement national qui peuvent traduire des méthodes ou manières de voir non conformes aux vues admises dans la généralité des pays.

5,21 Standardisation

La standardisation est un élément essentiel de la diminution du prix de revient. Sa généralisation dans les pays peu développés semble plus facile que dans les pays à population dense, où la construction est souvent tributaire des conditions existantes (configuration des abords ou existence des appuis pour les ponts, exiguité ou conformation géométrique des terrains à bâtir, etc.). La standardisation permet au bon amortissement de l'équipement et conditionne les possibilités de préfabrication.

5,22 Equipement

L'expérience prouve que tout équipement spécial (coffrages métalliques, engins de manutention spécialisés) qui n'est pas commun pour tous les chantiers est souvent mal amorti.

Les conditions d'une utilisation rationnelle de l'équipement sont :

- l'existence de programmes assez vastes pour permettre un amortissement avantageux,
- la standardisation, qui permet de diminuer le nombre de types différents d'éléments et par conséquent d'augmenter le nombre d'unités de chaque élément à fabriquer,
- la possibilité pour l'équipement spécialisé d'être utilisé par différentes entreprises. Après l'exécution d'un premier marché, cet équipement pourrait, par exemple, devenir la propriété de l'Etat, sa fourniture aux entreprises soumissionnaires devenant une clause des marchés ultérieurs,
- accords entre pays pour l'utilisation du même équipement.

5,23 Assistance technique pour l'exécution des travaux

Le premier problème à résoudre est de déterminer si l'utilisation du béton précontraint apporte des avantages dans la réalisation d'un programme donné. Pour la solution deux voies sont possibles :

- organisation d'un concours dans lequel tous les matériaux soient admis,
- si le projet est établi par un ingénieur conseil dans son ensemble, consultation d'un bureau d'études spécialisé pour déterminer si l'exécution de certaines de ses parties en béton précontraint est rationnelle.

L'assistance technique portera ensuite sur l'étude des parties précontraintes. Cette étude sera faite soit par un bureau spécialisé en vue d'une adjudication, soit par le bureau d'études de l'entreprise adjudicataire à la suite d'un concours.

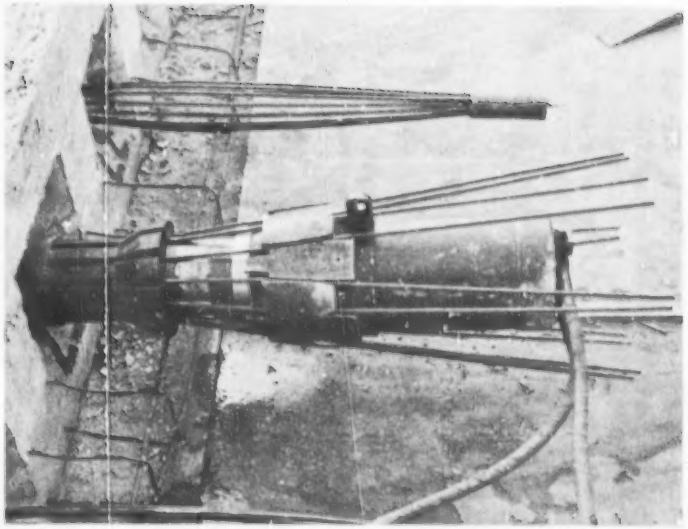
L'exécution des travaux est menée par des entreprises expérimentées adjudicataires qui s'associent souvent avec des entreprises locales en fournissant les cadres.

5,24 Formation des cadres locaux

Les ingénieurs spécialisés en béton précontraint sont formés dans les pays avancés dans l'utilisation du béton précontraint. Une connaissance préalable de la langue du pays choisi pour les études rend le séjour plus profitable et en diminue la durée, donc les frais.

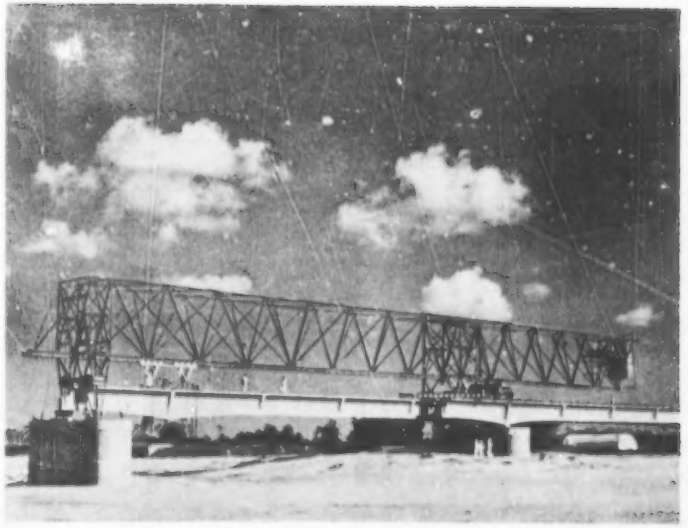
Plusieurs pays organisent des stages d'études de béton précontraint. En France un stage du Service de Coopération Technique du Ministère des Finances et des Affaires Economiques fonctionne depuis 5 ans et a été suivi au coffre de 10 sessions par 366 ingénieurs étrangers. La formation est également faite au cours de stages auprès de bureaux d'études et entreprises spécialisées.

L'enseignement est également fait dans les pays intéressés mêmes par des professeurs étrangers au cours de stages ou de conférences. Un excellent moyen d'acquérir des connaissances est de suivre les études de projets et les travaux exécutés dans le pays.



1. Vérin type "Freyssinet" pour mise en tension de câbles de précontrainte.

2. Pont sur le fleuve Coleroon (Inde). Mise en place d'une poutre préfabriquée à l'aide d'un appareil de lancement.



3. Pont sur la Boa (Côte d'Ivoire)

4. Canal d'irrigation surélevé en éléments préfabriqués

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PRESTRESSED CONCRETE IN DEVELOPMENT AREAS

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PRESTRESSED CONCRETE IN DEVELOPMENT AREAS

By

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1. Brief definition of prestressed concrete

Unlike conventional reinforced concrete with its mild or semi-hard steel cast in, prestressed concrete uses hard steels of high tensile strength, stressed close to this level. There are two main methods of prestressing:

Pre-tensioning, using wires bonded to the concrete, in which the wires are stretched before the concrete is poured. This process is used for mass-producing floor joists, columns, piles, irrigation channel units, etc.

Post-tensioning, applied after the hardening of the concrete. This method, requiring no fixed plant, is used in structures poured in situ, or prefabricated on the site.

2. History

The birth and development of prestressed concrete are based on the work of Eugène Freyssinet (1879 - 1962). The first work dates from 1933 - 35 (France, Algeria, Germany). The beginning of the current upsurge of development was in the early post-war years. Prestressed concrete is now universally used, and most countries have published rules for its use. Hard steels are being produced, and construction methods constantly being improved.

3. Engineering and cost advantages of prestressed concrete

3.0 Its precompression eliminates the cracks from ordinary prestressed concrete, which is therefore a homogeneous material. This absence of cracking makes it waterproof, which is particularly important for structures in water or at the seaside.

3.1 The prestressing force submits the materials to stresses higher than those imposed by loading. It is therefore a preliminary test of the entire structure, which no other building material enjoys.

3.2 The saving in weight of steel in relation to ordinary reinforced concrete, in bridges for example, is about 70%, resulting in a cost reduction of 26% which enables considerable savings to be made. There is also a reduction in volume of concrete of 10 to 20%, as compared with reinforced concrete. These savings in materials lead in turn to savings in transport costs and in foreign exchange.

3.3 Prestressed concrete structures are lighter and of larger span than reinforced concrete ones, for beams of the same height.

3.4 Prestressed concrete is easily precast.

4. Analysis of prestressed concrete achievements in development countries

4.0 The development of prestressed concrete in a country does not always correspond to the general development of the country from other aspects. Thus in India, prestressed concrete has been developed with benefit to the economy of the country as a whole.

4.1 Prestressing suits bridge construction particularly, because the quantities of steel used are large. It is in bridge building therefore, that prestressing develops most quickly. In India, 460 spans of road bridges have been built, as well as many railway bridges, making large savings in cost and foreign exchange. Modern methods (prefabrication of beams and their launching into position) have been shown to be economic even in this country of abundant cheap labour. India now has technically-trained teams of her own people.

The saving in materials has been particularly valuable for bridges on the Ivory Coast and in Madagascar (Malgasy).

The large bridges built at Abidjan, Douala, Goya-Melanville, and Bamako, have shown that local labour can be used for prefabrication. Bridge building in undeveloped countries has been satisfactory, and will continue to develop.

4.2 Prestressed concrete hydraulic structures have the advantage of long life because of the absence of cracking. Many ports have such structures, including the flooring of open or closed jetties, caissons and piers.

4.3 The construction of a factory for pre-tensioned precast concrete presupposes an adequate market and transport facilities. Development countries are thus not favourable sites for pre-tensioning, unless development plans ensure a market (urban development, construction of electric power lines; irrigation etc.)

4.4 The application of prestressed concrete to irrigation lies in the production of precast units for flumes and high-pressure pipes.

5. Future possibilities

Prestressed concrete has not yet acquired the volume of work that could be justified by its advantages. The number of buildings using it is still small in development countries. Its application is helpful in industrial buildings with large spans and heavy loads, in thin shell roofs, or floor beams. Its use for reservoirs is not common, despite its advantages. To promote the rational development of prestressed concrete in development countries, the following is necessary:

adoption of international regulations for design and construction;

support standardisation to the maximum;

full use of equipment so as to amortize it quickly;

Technical help can include:

investigation by specialist organisations into the application of prestressing to specific programmes, to decide for or against its use;

training of specialist engineers either by courses in countries advanced in prestressed concrete techniques, or by specialists brought to the country itself.

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